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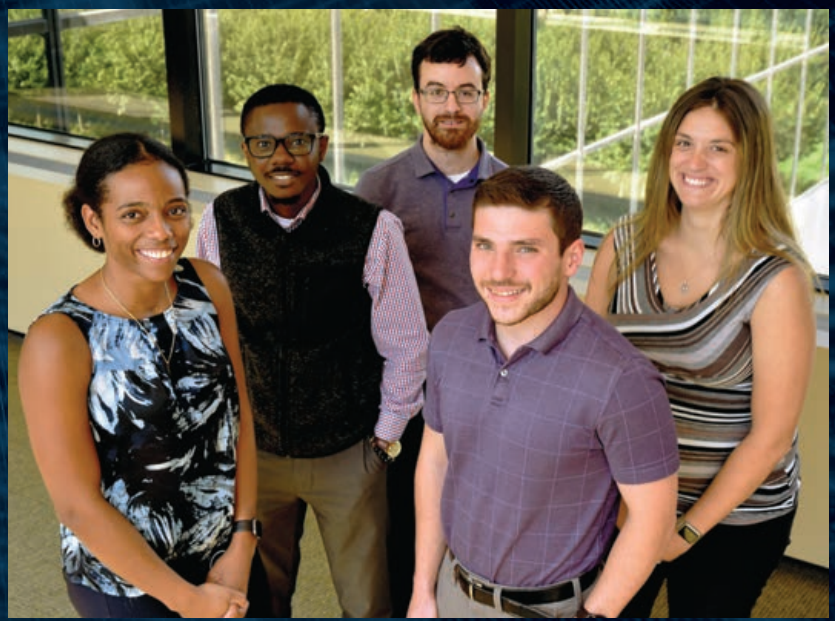

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PUBLIC UTILITIES FORTNIGHTLY
Impact the Debate

November 11, 2019 • Volume 157, No. 14

Cover photos: Ten of the forty-six qualifying nominations – six innovators and four teams of innovators – are pictured on the cover. We wish we could have fit all the nominated innovators. On the top row, from left to right, is San Diego Gas & Electric's team of Chris Arends, Carrie Bowers, Katie Giannecchini, Steve Vanderburg, Don Akau and Michael Deleo, and Ameren's James Pierce. Below Pierce, from left to right, is Exelon's team of Keith Steger and Bryan Uber (teammate Jason Zola not shown), and the D.C. PSC's Patrice Jones Hunter. Below them is Arizona Public Service's team of Vanessa Fierro, Marissa Pacheco, Elsa Reynoso, Candice Renner, Brandy Leisin and Jenna Nelson, left to right as always. In the lower left, going clockwise from the corner, is Washington Utilities and Transportation Commission's Danny Kermode, Southern Company's Clifton Black, Portland General Electric's Larry Bekkedahl, and Ameren's Bhavani Amirthalingam. In the lower right, PSEG's team of Julie Duncan, Emmanuel Ansah, Tim McCaffery, Sal Orsino and Lisa Garcia.

Sam Insull, Bill Nye, and the Urge to Innovate

Recapturing Our Industry's Spirit

BY STEVE MITNICK, EDITOR-IN-CHIEF

Today, the eleventh of November, is Samuel Insull's Birthday. We're in Insull's debt for his many breakthroughs for the utilities industry, in the late nineteenth century and the early twentieth. Not the least of which is, literally, the innovation of utility regulation.

From Insull's memoirs,

"I was president of the National Electric Light Association [predecessor to the Edison Electric Institute] in 1897 and 1898. At the annual convention of the Association, held in Chicago on June 7th, 1898, I advocated public control and private operation, or in other words, the regulation of public utilities. I was criticized by a great many people in the public utility business at the time, as I was of the first men occupying a prominent position in the industry to take the position that, as the business was a natural monopoly, it must of necessity be regulated by some form of governmental authority. I have consistently taken this position as I am a strong believer that a business in connection with which competition is an unsound economic regulator, its affairs must be subject to proper governmental authority."

He wrote his memoirs in 1934 while awaiting trial. Insull, later acquitted of all charges, had been blamed by many including President Franklin Roosevelt for the collapse of his vast utility holdings and to an extent the great depression.

One of the most prized documents in Public Utilities Fortnightly's archives is the Federal Trade Commission's schematic of those vast holdings as of 1932, two years prior. It shows the origins of most of today's electric and natural gas investor-owned utilities. A year after Insull's writings and his acquittals, Congress enacted the Public Utilities Holding Company and Federal Power Acts of 1935, not coincidentally.

Imagine if Insull's decade-long battle for utility regulation, which was won in Wisconsin first and then in other states commencing in 1907, had flagged. The investor-owned utilities like Insull's had struggled to raise sufficient capital to fully build out the grid – beyond the most prosperous communities – amid competition, the huge sums needed, and the vagaries of customer demand. And whenever an investor-owned utility emerged from competition, becoming a monopoly, the public outcry was enormous.

Suppose Insull's innovation of utility regulation hadn't taken hold. The utilities industry wouldn't have gained access to the capital needed to electrify most of the nation's population.

This wasn't a problem for the municipally-owned utilities of the early twentieth century. Though they too were extremely capital-constrained. And then the Panic of 1907 drove many of them into a severe crisis.

Suppose that Insull's innovation of utility regulation hadn't taken hold. Then the utilities industry wouldn't have gained access to the massive amounts of capital that was ultimately needed to electrify most of the nation's

Steve Mitnick is President of Lines Up, Inc., Editor-in-Chief of Public Utilities Fortnightly, author of "Lines Down: How We Pay, Use, Value Grid Electricity Amid the Storm," formerly an expert witness that testified before utility regulatory commissions of six states, the District of Columbia, the Federal Energy Regulatory Commission, and in Canada, and a faculty member at Georgetown University teaching undergraduate microeconomics, macroeconomics and statistics. He's been around awhile but not as long ago as during the industry's first growth spurt of innovation.

population by the nineteen thirties. Regulation made that happen. (Though, the expansion of utility service into the countryside would require the federal government's intervention via the Rural Electrification Act of 1936.)

Insull's career spanned the utilities industry's first growth spurt of innovation. From when Thomas Edison hired Insull as his personal secretary in January 1881 to the nineteen thirties, the period was a frenzied race of creativity and invention. However the decades that followed are better characterized as consolidation, incremental advancement and execution of the dreams of Thomas Edison, Samuel Insull, George Westinghouse, Nikola Tesla, Charles Coffin, Owen Young, etc.

But now let's turn to the utilities industry's second growth spurt of innovation underway in our day. Innovation is clearly in the air. For instance, the PUF team attended Exelon's ginormous annual innovation expo, as usual, this year on the tenth of October. There were gigawatt-hours galore of energy, enthusiasm and excitement among the thousands of utility employees at the innovation expo. Take a glimpse in a photo-story that follows.

While we were there, we got to see the especially energetic keynote speaker, Bill Nye the Science Guy. Nye's theme was, we can change the world! He shouted this slogan several times during his rousing speech. The audience – perhaps a thousand utility employees strong – reacted with glee each time.

Nye perfectly captured the spirit of the utilities industry. Our spirit during the industry's first growth spurt of innovation, concluded some ninety years ago. And our spirit during the industry's second growth spurt, commencing only a handful of years ago.

Utilities are unlike other businesses. Sure, investor-owned utilities have shareholders, quarterly reports, dividends and the like. But they're more accurately public service organizations. The utility people I know are really dedicated to their communities. And well aware of the almost unlimited potential of electric service to enhance our lives. Utility people are at their best when they're innovating to further fulfill that potential to, as Nye says, change the world.

And that's what the hundred and thirty-seven Fortnightly Top Innovators 2019, all of them celebrated in this issue of PUF, are doing. They're changing the world. Look through those pages and see for yourself how they're doing it.

> That's what the hundred and thirty-seven Fortnightly Top Innovators 2019, all of them celebrated in this issue of PUF, are doing. They're changing the world.

Oh, one more thing about Samuel Insull and Exelon. Insull headed Exelon's predecessor company, Commonwealth Edison, over a hundred years ago. How about that? PUF


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Visiting EPRI Innovators, in Charlotte

A Special Tour of
One of the World's Top Energy Labs

Public Utilities Fortnightly's editor-in-chief and managing editor, Steve Mitnick and Lori Burkhart respectively, were given a special tour of one of the world's top energy labs, at EPRI's sprawling campus in Charlotte, on the second of October. It was a day filled with wonder with one remarkable demonstration after another by some of the world-class scientists and engineers who innovate there. Though we felt it could have used a gift shop so we could have brought home souvenirs from the experience. Aside from the fascinating interviews and photos that follow herein.

You might just feel like you were with us on that special tour. Check out the mechanical testing and welding labs that exist nowhere else on this earth. And the incredible test devices that seem like they come from a science fiction movie. We did think more than once that one of those super cool high-tech tools would look mighty nice on our garage workbench.

Mechanical Test Lab

PUF: Tell us about this lab.

Alex Bridges: Here in the mechanical test lab, we're mostly focused on high temperature testing. Everything in here is running hot. We've got furnaces on most of the machines you see.

There are a couple of things that we don't have any furnaces on, but we have them on the majority of the machines in here. We have about twenty machines roughly, and we have another ten that we're getting this year. We've really built out over the last few years. We're expanding back behind this wall. We should have about sixty to seventy different frames in the next three to four years.

PUF: Why are they hot?

Alex Bridges: Have you heard of the term creep testing? Or are you familiar with tensile testing? You usually have a metallic test sample so we're looking at a variety of materials. I'm in the generation side on the materials and repair group.

We're focused on research with different materials that are used in the power plant. We're looking at things like grade 91, grade 22 and a lot of these materials that are used in hot sections of the boiler.

PUF: That could be like a natural gas or coal plants.

Alex Bridges: Yes. It could be either natural gas or coal plant.

PUF: You don't want things to crack and break.

Alex Bridges: We're looking at, how can we understand how that material is going to behave in the plant and can we estimate how long that's going to last before a catastrophic failure occurs, or before it leaks or before a crack forms? If a crack does form, how long is that crack going to hold and things of that nature.

PUF: Maybe in the old days they would wait until something breaks and you've got to fix it.

Alex Bridges: Yes. We already have non-destructive techniques and things like that. In here we're doing destructive testing.

I'll show you some. It's a standard sample you'd run like a tensile test, which you would just apply a load until the material breaks. But in this case, we're applying a constant load. We're not increasing the load over time. So, there's a dead weight on this. So, if I apply some weight and just leave it there, then heat it up, over time this slowly elongates and that's called creep. So, this is a creep testing.

We're trying to understand when you make your material, how does that affect how it's going to react in the environment of the power plant.

PUF: Why do you put weights because in power plants, there's pressures and weights?

Alex Bridges: Yes. If you imagine the boiler water, that eventually turns into steam. The steam goes through the boiler. The boiler carries it to large pipes and those large pipes carry very large volumes of steam.

That steam flowing through the pipes is causing the material to have pressure against the walls of the pipe. That pressure against the walls of the pipe is at high temperatures. There's a damage mechanism known as creep, which means it slowly elongates over time. Over a thirty-year period under those high temperatures and pressures, it's slowly deforming over time.

PUF: When you're doing all this, do you ever have an aha moment, oh that's it, we thought it was working in a different way but really it works this way.

Alex Bridges: Yes. When, when we do this type of testing, there are different modes of damage that form and the crack may form differently or the damage may form at a different location.

So, we're looking at the microstructure in the sample, which there are different grains, there are different particles that are

There are regulations that you have to use the renewable energy when it's being generated. Now your fossil plants have to cycle up and down. That can change the stresses on the materials. It can cause fatigue.

there, depending on how the material was fabricated and what was the process. If they did a forging process versus a casting process, that can change the way the microstructure inside the material and the structure of the material can be different and then the damage can form in different locations.

We're trying to understand when you make your material, how does that affect how it's going to react in the environment of the power plant.

PUF: Oftentimes EPRI does work in collaboration with utilities. When you do, you may have many utilities that say, oh here's what we've got at our power plant. How does that work? Do they come in and visit?

Alex Bridges: We have power plant people come in all the time. We give them tours. It helps us show where we're leading some of our research. A lot of power plants have similar materials in their power plant.

Different types of steels mostly are the area of research we're focused on. So, there's a variety of different steel that's been developed over time and over time we've seen similar problems across power plants. It works well when we have the power plants fund us. They all have similar issues.

You can leverage that research and provide that research to all of the utilities because they're having similar problems. Our group is focused on strictly materials and any of the materials issues that you would see in the power plant, mostly on the hot side. But we're starting to get more involved with renewables.

PUF: What's that about?

Alex Bridges: Wind turbines have material issues.

PUF: They do. In fact, that's important for them.

Alex Bridges: So, if you had a large gearbox, you can have wear on that gearbox. Trying to understand what kind of material you should use for these very large gearboxes is an issue. There are a lot of different materials issues across power generation, whether it's renewables, or fossil.

PUF: The common issue is, whether you're putting up a wind farm or you have a gas turbine combined cycle, you want that operating under demanding conditions for twenty to thirty years, right?

Alex Bridges: Yes. If you look at the coal plants, many are operating forty to fifty years. They still have the original material in there. So, they want to know, are we still okay using this original material. Consider flexible operations, that's when the plant cycles up and down. That's a huge deal right now.

In renewables, there are government subsidies in place for renewables, and there are more renewables. There are regulations that you have to use the renewable energy when it's being generated. Now your fossil plants have to cycle up and down. That can change the stresses on the materials. It can cause fatigue.

We're looking at what are those impacts on all kinds of things. We are focused on; how does it affect the grid? We're focused on how's the material being affected. It affects every bit of research that's going on in our generation side of things. That's the holistic view of why we're doing some of the things we're doing. We get down into the super dirty details and specifics.

There are very few people doing this type of testing. The other industry that would do creep testing would be the aerospace

industry. We have airplane engines that are operating really hot.

PUF: Then each machine is testing a different material?

Alex Bridges: The machines test different materials. We have this design. We then go to big stuff. This is extracted from a very large pipe. Then there's a weld here. When we pull this, what happens is damage forms adjacent to that fusion boundary of the weld.

Because when you put a weld in, you're putting a lot of heat into the material and you're changing the local properties in the original material. So there's a gradient between what the structure of the material looks like and that's where damage is, preferentially before it initiates it's adjacent to that weld typically.

We also look at heat treatments. If I put this weld and change the properties, I can reheat treat this, to get a structure that I would rather have that has better resistance to damage.

So, we look at different heat treatment processes and then we'll test those and we can go to big matrix and see, okay I did this heat treatment, and this is what I got. That's a high-level approach.

There's been a lot of research in that area. So now we're looking at things like, oh, can I change my welding process? Then I don't have to get a heat treatment, because if you think of a weld you make a bead and you make another bead.

You're applying some level of heat to each pass you make. So, you can use that as a heat treatment depending on how you control the heat and how you control your past travel speed. That's something else we can look at and test and evaluate.

PUF: Let's talk about this machine, it's an X-ray machine but it does what?

Alex Bridges: It's an XRF machine, so we're using x-rays as a source to gather compositional information about a material. Here you're looking at a weld.

PUF: Compositional, as in how much salt and sugar is in the recipe?

Alex Bridges: Exactly. So, how much of those elements like iron and chromium that are in certain steels. A lot of these materials are fabricated with different types of compositions to get certain types of properties. Depending on those elements that are in material, that can influence the properties. We're using this to map things like welds, so this is the same piece here.

This was a pipe welded to another pipe with a certain type of filler material and there's a gradient between, so this is two different materials that are welded to other materials.

PUF: It's important to know what the mix is of the steel?

Alex Bridges: If it has more of this or that, then you're going to have poor properties or if it has more of that over something else you may have a variation in properties. You'll have different properties based on those different steels and if it's operating at high temperatures and pressures, you want to know is that material going to hold up to those conditions that it's been operated at.

This is just another tool that we can use to evaluate certain things that would have an influence on properties. So, you can actually see this is chromium, and there's a lot of the chromium. And then you can see a variation in the weld too. ❍

Welding Lab

PUF: Mitch, what is this machine?

Mitch Hargadine: This is a Liburdi Diametrics H head. It is a machine TIG process, so it is the TIG, Tungsten Inert Gas, welding process on a semi-automated programmable machine. You can set your travel disc through your travel rate, your oscillation, all the weld parameters that you would normally have. Essentially, you're taking the human element out of the welding process.

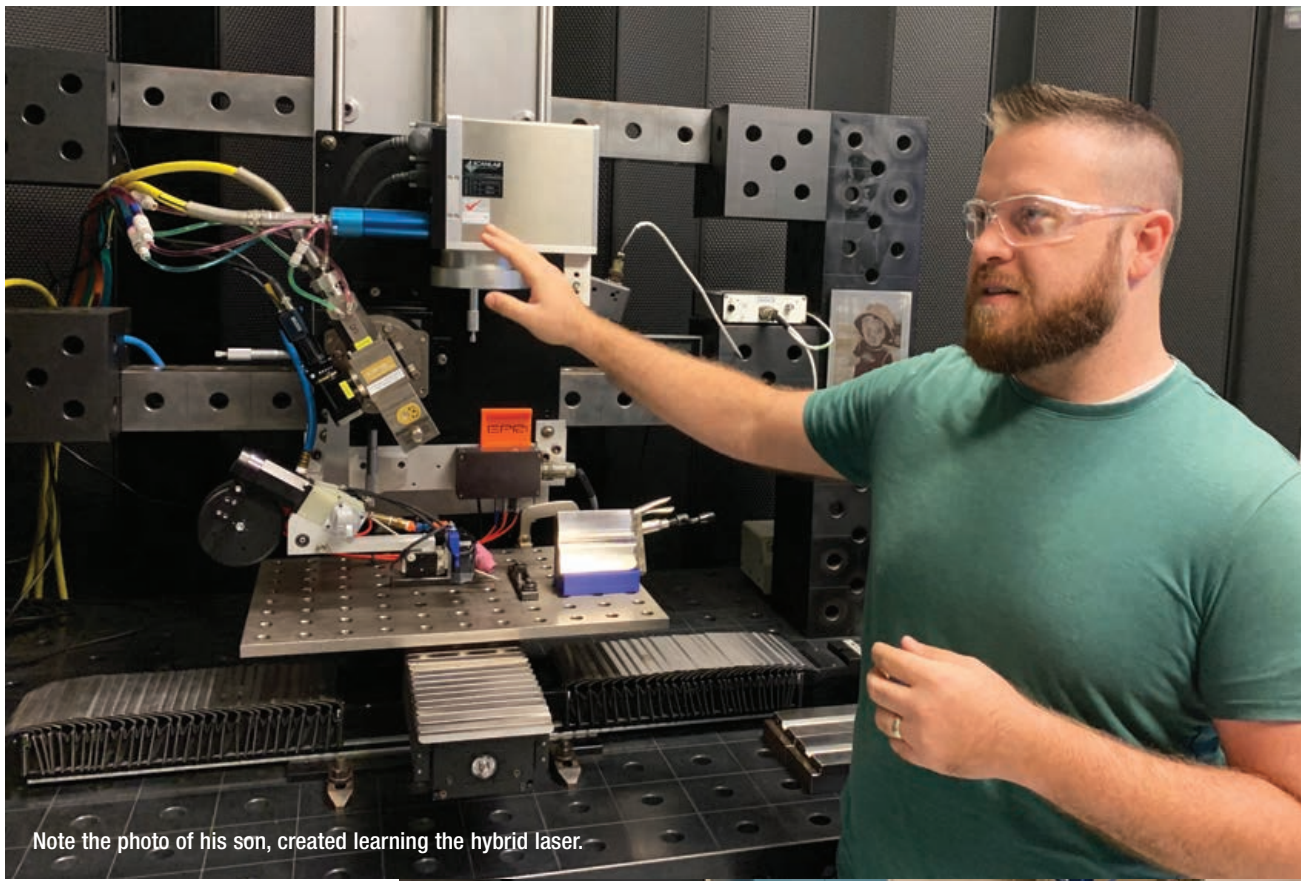
We've got the Gold Track VI over here, which is our welding power supply. That's the workhorse. That's where you enter all your data. The FireView sitting on top of it is essentially a vision system.

The vision system allows us to remotely weld and control this system. We can set up cameras on the weld head, and if you have cables long enough, you can control the welding a few hundred yards plus away from where you're actually welding.

That's the standard process. Among the videos that we have up is one of the Magstir (magnetic stirring) process. What you can't see is there's an addition to this head that sits around the tungsten. The tungsten is your electrode, which carries the current and creates a cone-shaped arc of energy that is melting the base material and your wire that's coming in.

PUF: It's super precise, this kind of welding?

Mitch Hargadine: It's very controlled. We'll get to even more precision when we get into lasers. But what you don't see is a magnetic manipulation head that is in addition to your standard unit.



Note the photo of his son, created learning the hybrid laser.

It has four poles that are difficult to see and, because we're using electricity, it's creating magnetic fields.

By alternating the poles, the current and the poles, you can manipulate the arc. You see how it's spinning? That's the manipulation through the poles of the Magstir. What this is doing for us is, as it solidifies, because we're stirring and mixing the arc, we're getting a smaller grain structure as it solidifies, which gives us a lot of positive properties. All it's doing is manipulating magnetic field into arc. Everything else is a normal operation.

PUF: Steve, what are we looking at here?

Steve Tate: This Gleeble is resistance heating and hydraulics to both heat, cool, push, and pull a sample to simulate welding processes with much better control than you can get in a weld. Say, in a weld you want the properties of a specific region, but you can't get a sample big enough to get a mechanical testing sample. Well, you can use this to replicate that exact thermal cycle on a bigger sample that you can use for mechanical testing.

Essentially, you're taking the human element out of the welding process.

– Mitch Hargadine

PUF: You mean it's a computer modeling of the weld?

Steve Tate: Not computer. It's physically simulating, thermally, and mechanically simulating.

PUF: Even though you don't have the exact material?

Steve Tate: Well, you can use the exact material composition and then you can replicate whatever thermal cycle you desire.

Mitch Hargadine: This is our first laser cell. It's our hybrid laser system. I'll give you an overview of the project first.

PUF: You created a picture there.

Mitch Hargadine: Yes. This is actually my son. When we get the equipment in, we have a brief window when we're learning how to use it. This is our hybrid laser system. We call it that because we are welding with two different lasers. We have our primary laser head and we'll get to the video that describes it a little bit better.

PUF: Two at the same time.

Steve Tate: The red one is the primary.

Mitch Hargadine: This is your galvanometer scanning laser and your primary laser is applying your weld. Your secondary laser is creating a heat treatment directly behind the solidifying weld and puts the main weld bead in compression. So, your secondary laser isn't melting anything. It's just reheating.

That reheating applies a compressive force on the weld so that the weld bead has a compressive force on it as it solidifies.

PUF: To make it a tight weld?

Mitch Hargadine: Yes. This is all designed to be used for welding on highly irradiated materials. One of major issues is when you're welding on highly irradiated materials you get a helium diffusion into the grain boundaries.

This Gleeble is resistance heating and hydraulics to both heat, cool, push, and pull a sample to simulate welding processes with much better control than you can get in a weld.

– Steve Tate

If they consolidate too much, they can form cracks in it as it solidifies. Cracking needs a couple of things to form and propagate. One is being a tensile force. We put the weld in compression, so it doesn't have the tension to form cracks.

The other thing that we're using to help mitigate that is low heat input into the base material, into the irradiated material. That's why we're using a laser welding process versus an arc welding process.

Steve Tate

PUF: It's a lot less hot, is that right?

Mitch Hargadine: A lot less heat is being applied. This is an example.

PUF: Most of the energy is being used as energy.

Mitch Hargadine: Yes. It's not a hard process.

PUF: It's not being lost as heat.

Steve Tate: You get a much higher energy density and then that energy density lets you transfer more into the part instead of losing some of the energy.

Mitch Hargadine: As you can see, these are very small weld beads. It's about the tenth of a size or smaller than a standard TIG welding. What you get with that is low dilution. So, on an irradiated material, you're not diluting as much of that irradiated material into your weld.

PUF: Why wouldn't you use these laser weldings all the time? Why ever use the electric kind of heat?

Mitch Hargadine: We're trying to get to that, but we're a long way off. But the main reason is mobility of laser equipment isn't there yet. The other thing is it's typically a smaller weld. So, if it's a weld that you can perform with an arc welding process, you're going to get higher depositions and faster welding times, with lower costs. The equipment costs with laser equipment is much higher as well, versus standard arc welding. ❍

T&D Conductor Test Lab

PUF: Tell us about these sensors.

Sam Harrell: EPRI developed a full fleet of sensors. I brought a few of them out here today. This is the leakage current sensor. You could put it on your insulators in your substation.

When you see the current start to rise, it will alert your base station. They will know to go in and wash the insulators and save you from potential flash over. We have the acoustic emission sensors that we have built and this will go on to your transformer that'll help you be aware of any arcing or anything like that.

For the ballistic sensor, it lets you know that someone has fired shots at your transformer. This sensor can distinguish a gunshot. It will pick it up and throw out the bad stuff. It's accurate and can detect the difference between a shot and a rock hitting it. But it has to go through certain thresholds before it can activate.

This is our conductor splice sensor, which goes on your conductors and it has a thermocouple that allows you to measure the temperature of the conductor. We can also measure the current flowing through your conductor. The sensor harvests power off the lines so you don't have to charge it. It can last two to three months without the conductor being energized.

This sensor can look at the inclination of your line, and it can look at the galloping of your line, especially in the colder areas where you have icing problems. If you've got a line down, it knows it's down.

If you lose current, it's going to say, hey, I'm not feeling any more current in the line. For the inclination, it detects it's hanging down at ninety degrees.

I'm just giving you an overview of some of these. All these were developed and built in-house.

This is one of biggest test setups in the lab. This is our conductor test bed. There are eight lines across. We started out with one level and this testing grew so much that we've got three levels in here now.

Some of these lines are tensioned up to fourteen thousand to fifteen thousand pounds. That's about twenty-five percent of the rated breaking strength of these conductors. But what we're looking at is what is on the conductor market today, as they have a lot of different conductor manufactures.

A lot of people are looking at the new carbon core conductors. It has a stronger core. It has more aluminum and that allows it to carry more current. In comparison, this is 795 Drake and it has a steel core which is not as strong.

The new style conductors on the market, have benefits of a carbon core, where no current is carried.

PUF: How many kilovolts can be put through that?

Sam Harrell: I can't tell you right off the top of my head what the max is, because we're not pushing to their max. What we're testing here is how they react on a long-term cycle. I completely age these conductors. I spend about a year and a half to age them about forty years.

We're looking at the temperature of this conductor. That's what we're concerned about is how hot the conductor or accessory gets. At a utility, you have levels that they're not going to let the conductor go above. If it does, then they'll go do an inspection and then possibly replace.

The old-style conductor, which most utilities have up, is a galvanized steel core and aluminum alloy strands. These are some of the new style conductors on the market. The benefits with

Chuck Lease with EPRI U.

John Seifert shows off the latest in innovative technology.

From left, EPRI's Sam Harrell with PUF's Steve Mitnick.

I completely age these conductors. I spend about a year and a half to age them about forty years.

these is that they have a carbon core, where no current is carried.

However, here, it's going over a long span, over a river, or over swamps. You can string this conductor up over your interstates. It doesn't have near the sag. But because of the amount of aluminum in the conductor, it can carry more current. So, they call these high temperature, low sag lines.

We have several different manufacturers that we're testing their conductor. This is one type of carbon core made by Mercury cable.

This is a C7 conductor and it has a stranded carbon core. You can see how the strands react when it's compressed. This is on the inside of a splice where you hook one together. Then you have the outer sleeve where it carries the current.

Here are all the different manufacturers of carbon core conductors and we're evaluating to see how they perform under these extreme temperatures. As you can see, some of these are rated up two hundred degrees Celsius. This particular ACSS conductor can run over two hundred and fifty degrees Celsius.

A normal steel core conductor operates at ninety-three degrees Celsius.

PUF: That's good, because if there's a higher level that it's rated for and there's variations, it's not going to go bad.

Sam Harrell: That right. That's why we're looking at the heat and how it effects not just on the conductor, but the accessory where you clamp it together. That's where your failure normally happens.

We're testing not only the conductor, but the accessories and how they react at their maximum rated temperature. In the middle level here, is where we use mitigation. Notice the shunts and thermal couple wires. We can monitor the temperature profile around those shunts.

If you have a bad splice, you can put the shunt on it to divert that current around that splice. Also, it has good mechanical strength and may allow you to run until it is convenient for an outage. We're not only proving how good they are electrically, but we're looking at them mechanically. This first one here is a PLP shunt and it doesn't even have a splice in it.

A normal conductor is put together with a two-piece splice and that holds it together. We're proving that this shunt can carry the current electrically across with no problem and support the weight. If a splice failed, it still could do its job. Those are just different manufacturers of different types of shunt devices.

PUF: You have to tell the companies the good news and the bad news about their products.

Sam Harrell: Sure, we're totally non-biased. We don't make recommendations to the utilities whatsoever. If you're a member of EPRI and ask us to evaluate this equipment, we will evaluate that equipment. We'll give you the data.

You take that data and look at it and you make a determination whether that's the right fit for your company or not. Now your question about the manufacturer, if we've got it in here and it is giving problems, we're going to provide them that data.

We worked with the manufacturers some, but for the most part, we're here for the utility. A good example is that if we had

(Cont. on page 67)

Exelon's Innovation Expo

Thousands of the Utility's Innovators Gather in D.C. on October 10

Bill Nye, the science guy, delivers keynote.

Exelon is a large utility, sure. But it still amazes us that it holds a ginormous annual innovation expo for a few thousand of its employees. This year, Exelon took over Washington D.C.'s convention center on the tenth of October. It was there and then that the latest competition took place among several hundreds of innovation exhibits all vying for the votes of their peers and then a guest panel for the top three awards in specific categories.

Though this competition was the main attraction of the day, there was so much more to see and do at the expo. For one, Bill Nye the Science Guy gave an extremely funny keynote speech, though on the extremely serious subject of climate change. His theme, we can change the world.

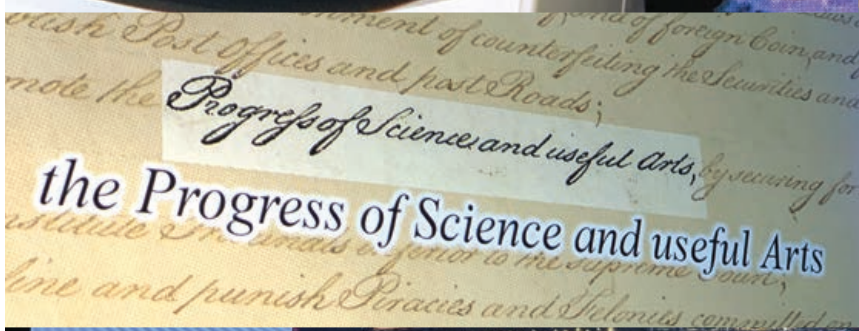
Panel discussions included innovative leaders like Ryan Popple of Proterra, a company electrifying the nation's buses, and James Chen of Rivian, a company electrifying the nation's sport utility vehicles and light trucks. And supporting companies exhibited at the expo too, like ABB, Accenture, Burns & McDonnell, Itron and Oracle.

It was said more than once during the day that a culture of innovation starts at the top. The leaders of the utility were all there, and enthusiastic. And we even spotted CEO Chris Crane checking out a few of the innovation exhibits. In the opening remarks that morning, he joked that, when seeing some of the high-tech demos, this veteran nuclear engineer knows to nod, even when the technical details are somewhat beyond his comprehension.

Panel on Electrification of Transportation, from left, moderator Calvin Butler, CEO, BGE, Ryan Popple, CEO, Proterra, Wayne Killen, Director Infrastructure, Planning & Business Development, Electrify America, Nadeem Sheikh, VP, autonomous vehicle program, Lyft, and James Chen, VP, public policy, Rivian Automotive, LLC.

Chris Crane, CEO, Exelon.

Robo greeter



Panel on Climate Change and our Planet's Future, from left, moderator, Joe Dominguez, CEO, ComEd, Bill Nye, the science guy, Barry Franklin, head of NA risk, Zurich, Bob Stout, VP and head of regulatory affairs, Washington, D.C., BP, and Kate Johnson, chief, green building and climate branch, D.C. Dept. of Energy & Environment.

Dinosaurs or Trailblazers, from left, moderator Joseph Nigro, senior executive VP and CFO, Exelon, Kevin Garlan, NA head of innovation, Citi, Thad Ewald, VP of corporate strategy and business development, Cummins, and Bob Welsh, VP, technology connector, Stanley Black & Decker.

Calvin Butler, CEO, Baltimore Gas and Electric.

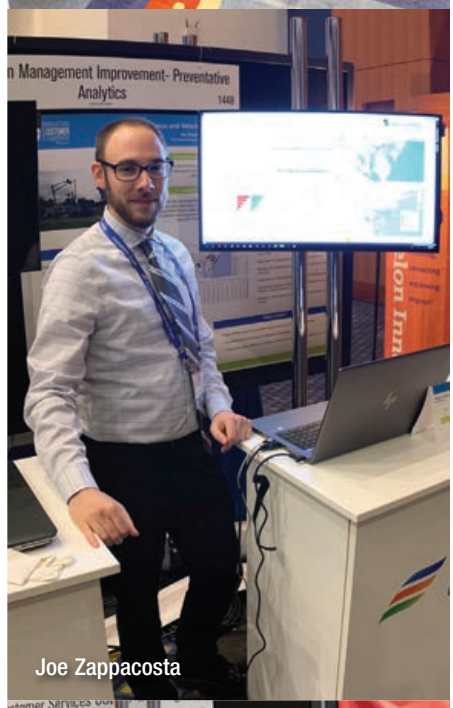
Bill Von Hoene, senior executive vice president and chief strategy officer, Exelon.

Dave Velazquez, CEO, PHI.

Chris Crane, CEO Exelon, looks at exhibits.

Explaining their creations.

Accenture shows innovations.



Joe Zappacosta

Burns & McDonnell showed innovations too.

Isabel Fabre and Harpreet Singh

Lauren Gordy

Carl Chatterton


Kevin O'Dowd


What do you see in your VR headset?

Tracy Favre & Colin McDonough

Ariel Nathan

Joseph Cohen

Fortnightly Top Innovators 2019

137 Innovators at 27 Organizations
in 46 Nominations

The forty-six qualifying nominations for this year's Fortnightly Top Innovators included one hundred and thirty-seven innovators. Twenty-three of the nominations – exactly half of them – were of an individual innovator. The remaining twenty-three nominations were of a group of innovators. The groups ranged from small two-person teams to large teams with as many as a dozen team members.

The one hundred and thirty-seven innovators work at twenty-seven different organizations. Including nineteen utilities, four vendors, two state utility regulatory commissions and two research entities.

The nineteen utilities? AEP, Alliant Energy, Ameren, Arizona Public Service, AVANGRID, Consolidated Edison, Consumers Energy, Eversource, Exelon, Holy Cross Energy, New York Power Authority, Portland General Electric, PPL Electric Utilities, PSEG, San Diego Gas & Electric, Southern California Edison, Southern Company, Western Farmers Electric Cooperative and Xcel Energy.

The four vendors are ABB, Itron, New Cosmos, Urbint. The two state commissions are the District of Columbia Public Service Commission and Washington Utilities and Transportation Commission. And the two research entities are the Electric Power Research Institute and Georgia Tech, which is also a fine university of course.

On the following pages, the forty-six nominations – whether of individual innovators or teams of them – are ordered alphabetically by the name of their organization. Starting with ABB's Luiz Cheim and ending with Xcel Energy's team with ten team members.

For this year's Fortnightly Top Innovators, among the forty-three nominations we selected the most outstanding – in our judgement – in ten categories. Specifically, we selected the Fortnightly Foremost Innovator in customer service, distributed resources, energy efficiency, environmental care, infrastructure safety, new technologies, regulatory effectiveness, smart grid, system efficiency, utility culture.

This year's Fortnightly Foremost Innovator in customer service is the team of Emmanuel Ansah, Will Barnes, Lauren Biernacki, Julie Duncan, Lisa Garcia, Sal Orsino and Jared Osorio of PSEG. They developed a comprehensive and easy-to-use real-time customer service interface for those customers with Alexa.

This year's Fortnightly Foremost Innovator in distributed resources is Larry Bekkedahl of Portland General Electric. He led the development of a virtual power plant within the utility's distribution system to enable integration of distributed resources at scale.

This year's Fortnightly Foremost Innovator in energy efficiency is Kristol Simms of Ameren. Under her leadership, the utility teamed with minority and women-owned businesses and community organizations to significantly increase efficiency opportunities for low and moderate-income customers.

This year's Fortnightly Foremost Innovator in environmental care is the team of Kirk Ellison and Jeffery Preece of the Electric Power Research Institute. They created a wastewater encapsulation technology to manage – over the long-term – wastewater at electric power sites.

The 137 innovators work at 27 different organizations. Including 19 utilities, 4 vendors, 2 state utility regulatory commissions and 2 research entities.

This year's Fortnightly Foremost Innovator in infrastructure safety is the team of Tom Langlois, Magdalena Michniuk, Anuja Nakkana and Kevin Wasserman of Consolidated Edison, Bob Laird, Bob Luben, Eric Toperzer and Daniel Smires of Itron, and Joe Deluca, Akira Nakao, Yoshinori Nishiie and Kazuya Saito of New Cosmos. The three companies collaborated to deploy nine thousand smart natural gas detectors in New York that alarm anyone nearby of a leak and the local fire department.

This year's Fortnightly Foremost Innovator in new technologies is Clifton Black of Southern Company. He established a grid visualization and analytics center to expeditiously demonstrate and evaluate new power grid technologies.

This year's Fortnightly Foremost Innovator in regulatory effectiveness is Patrice Jones Hunter of the District of Columbia Public Service Commission. She developed the energy supplier workshop and the integrated case management system.

This year's Fortnightly Foremost Innovator in smart grid is Luke Benedict of Exelon. He developed a real time alerts dashboard to alert operators of the distribution system if the alarms pass a threshold suggesting possible equipment damage.

This year's Fortnightly Foremost Innovator in system efficiency is Luiz Cheim of ABB. He developed a wireless inspection robot to maneuver through a liquid-filled power transformer.

This year's Fortnightly Foremost Innovator in utility culture is the team of Cynthia Butler Carson, Jennifer Downey, Wiley Elliot, John Jost, Paul Loeffelman, Ram Sastry and John Schwarck of AEP. They created a process working internationally to drive more start-ups, pilots and faster results from innovation.

Presenting This Year's Fortnightly Foremost Innovators

This year's Fortnightly Foremost Innovator in customer service: the team of Emmanuel Ansah, Will Barnes, Lauren Biernacki, Julie Duncan, Lisa Garcia, Sal Orsino and Jared Osorio of PSEG.

This year's Fortnightly Foremost Innovator in distributed resources: Larry Bekkedahl of Portland General Electric.

This year's Fortnightly Foremost Innovator in energy efficiency: Kristol Simms of Ameren.

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This year's Fortnightly Foremost Innovator in utility culture: the team of Cynthia Butler Carson, Jennifer Downey, Wiley Elliot, John Jost, Paul Loeffelman, Ram Sastry and John Schwarck of AEP.

Jeff Hanson, Alliant Energy

As director of environmental services and corporate sustainability, his team developed an Envision framework to identify ways in which sustainable approaches – in quality of life, leadership, natural world resource allocation, and climate and risk – can be used to plan, design, construct, and operate infrastructure projects. The framework has been applied to development of the Dubuque solar energy lab, redevelopment of a brownfield at the port of Dubuque, and pollinator species improvement at all infrastructure project sites (like incorporating natural prairie grasses and pollinator habitats into site restoration landscaping plans).

Adam Marxen, Alliant Energy

As manager of gas integrity and standards, his team partnered with the IT GIS support and operations groups to develop a vehicle methane detection project to proactively detect and record leaks on gas mains. Detecting and recording leaks was historically done by operations employees walking every foot of main with hand-held leak detection equipment or by driving over mains on a truck traveling two to three miles per hour. Recording leaks was with paper maps. The new equipment allows travelling twenty to twenty-five miles per hour and reads within twenty-five feet of mains.


Luiz Cheim

Luiz Cheim, ABB

In the power grids transformers division, Cheim developed the initial concept for the TXplore™ inspection robot and worked closely with the design team. It's a wireless robot that maneuvers through a liquid-filled power transformer with multiple on-board cameras and lighting. So a transformer doesn't need to be de-energized, drained of its oil, manually inspected, and refilled with oil. See the interview of Cheim later in this issue of PUF.

Cynthia Butler Carson, Jennifer Downey, Wiley Elliot, John Jost, Paul Loeffelman, Ram Sastry, John Schwarck, AEP

Formed in April, the international startup pilot management team to bring more startups, pilots, and faster results to the company. To do this, the team is participating in global accelerator programs including Free Electrons and Starter with a thousand startups from about sixty countries. Examples are a Dublin, Ireland startup transforming demand side resources into revenue opportunities for commercial and industrial customers, a British startup with software that detects daily behavior pattern changes by family members like the elderly, and an Australian startup with an advanced battery management system to repurpose retired electric vehicle batters for residential and grid support.

Bhavani Amirthalingam, Ameren

As chief digital information officer, she is driving the convergence of information and operations technologies, breaking down the two silos. With the network manager advanced distribution management system and ellipse asset performance management system, both from ABB, for storm preparation and service restoration and control center and asset management, Amirthalingam and her team have driven a broad range of critical utility functions to significantly greater cost-efficiency and responsiveness.

Atallah Alytim, Ameren Illinois

Natural gas storage wells nearly sixty years old were vertically drilled and in a residential area. Alytim found that storage could be relocated and drilled vertically and horizontally for improved safety, lower cost and increased gas capacity. Some of the new wells have already been developed and some of the old wells retired.

James Pierce, Ameren Transmission

Leading the unmanned aircraft systems department of more than fifteen drone pilots and information scientists, Pierce implemented drone inspections of the utility's eight hundred thousand distribution poles including two hundred and fifty thousand with infrared technology. Now his team is developing deep learning neural networks to interpret drone images like broken or rotted cross arms and bad pole tops. Plans are underway to integrate drones in renewable energy inspections and vegetation and forestry predictive modeling.


Kristol Simms

Kristol Simms, Ameren Illinois

Under her leadership, as director of energy efficiency, the utility teamed with minority and women-owned businesses and community organizations to significantly increase efficiency opportunities like free smart thermostats and home efficiency upgrades to low and moderate-income customers. She also launched an internship program for contractors and non-profits.


Lorne Poindexter

Rodney Hilburn, Ameren Illinois

As manager of the technology applications center, he has been a driver of several distribution system improvements, including microgrids, voltage optimization, electric vehicle charging, and transactive energy markets. For example, Hillburn led a cross-departmental team to install four voltage optimization control solutions. During a pilot, voltage was reduced 3.27 percent on average.


Rodney Hilburn

Lorne Poindexter, Ameren Missouri

Led by Poindexter, the Callaway Energy Center, a nuclear power plant, piloted and installed phase one of a wireless sensor and equipment monitoring system. The system will help transition the plant from timed maintenance – on a preset schedule – to more cost-efficient condition-based maintenance. It was the first truly wireless vibration monitoring system at an operating nuclear plant. The team is now installing wireless equipment to monitor thermal performance. Shout-outs to team members Clark Allen, Terry Becker, Eli Gerson, Eric Holzer, Zach Lamb, Casey Meyer, Ben Oguejiofor, Eric Olson, Brian Pae, Kyle Shoff, Deepak Suresh.


Vanessa Fierro, Marissa Pacheco, Elsa Reynoso, Candice Renner, Brandy Leisin, Jenna Nelson

Vanessa Fierro, Brandy Leisin, Jenna Nelson, Marisa Pacheco, Elsa Reynoso, Candice Renner, Arizona Public Service

This customer interactions team used a newly optimized speech analytics tool to score all customer calls for sentiment. That is, the customer's emotion based on word choice, tone and inflection. With this data, the team found a direct correlation between what was said by the customer – and the customer care employee – and the customer's satisfaction rating. Then the team did a pilot testing positive language. And then the team implemented this approach throughout the customer care center. Customer satisfaction rose significantly.


Kim Wagie

Kim Wagie, Arizona Public Service

Wagie is the director of digital transformation and, collaborating with the information technologies group, has implemented the utility's first robotic process automation, or bots. This has been applied to energy settlements for gas and power trades in the region's energy imbalance market, and in tax processes – for sales tax refunds for eligible manufacturers and tax savings from missed exemptions or vendors billing tax on exempt items. See the interview of Wagie later in this issue of PUF.


Mansur Ali Mohammed

Mansur Ali Mohammed, AVANGRID

As legacy bare steel and cast iron pipeline is being replaced, a new track and trace technology installs bar-coded devices on the new underground PVC pipes. Field personnel with hand-held devices use a special app to capture everything from the exact location and detailed features of new pipe infrastructure, system pressures, and leaks to data that can reduce costs using predictive machine learning algorithms, and efficient operation and information technology processes. As senior manager of IT architecture, digital and innovation, Mohammed led and implemented this intelligent pipeline's proof of concept.

Tom Langlois, Magdalena Michniuk, Anuja Nakkana, Kevin Wasserman, Consolidated Edison, and Bob Laird, Bob Luben, Eric Toperzer, Daniel Smires, Itron, and Joe Deluca, Akira Nakao, Yoshinori Nishiie, Kazuya Saito, New Cosmos

Undetected natural gas leaks can lead to devastating damage to a utility and its customers. In the past ten years, gas leaks and explosions in the U.S. have killed seventy-three people, injured four hundred and twelve and caused more than half a billion dollars in property loss. This three-company team collaborated to deploy nine thousand battery-powered smart natural gas detectors in New York with a secure standards-based industrial IoT platform and a revolutionary detector that sounds an audible alarm alerting anyone nearby and sends wireless detailed signals to the utility and the local fire department.

Shannon Morrow, Melissa Powell, Riki Shook, Teri Vansumeren, Consumers Energy

With Morrow coordinating the work of the utility's analytics, IT and marketing groups, and as scrum master, and Shook focused on hitting customer enrollment targets, and Powell and Vansumeren on enrolled customers' energy efficiency, this demand response team achieved remarkable results for a pilot. In a single week, the utility was able to reach its 2019 customer recruitment goal for smart thermostats (that leverages the energy usage optimization system of Uplight). When the grid was straining during heat waves this summer, the program was able to achieve over eighty percent load shift during these events without snapback.


Shannon Morrow

Kirk Ellison, Jeffery Preece, Electric Power Research Institute

Ellison and Preece took an innovative approach to concurrently investigate the fundamental chemistry needed to develop wastewater encapsulation technology and the applicability to electric power sites. Traditional wastewater management has centered around technologies like membranes and thermal evaporation. Now, a number of utilities are in various stages of planning encapsulation field trials and pilot trials that have the potential to significantly enhance long-term environmental quality. See the interview of Ellison and Preece later in this issue of PUF.


Kirk Ellison


Jeffery Preece


Patrice Jones Hunter

Patrice Jones Hunter, District of Columbia PSC

Currently a special advisor to Chair Willie Phillips, she will soon become chief of the office of policy and development. Hunter was responsible for the creation of the energy supplier workshop – an online tutorial on consumer protection and other rules for competitive electric and gas suppliers, the renewable energy portfolio portal – to file applications to become a certified renewable energy generator in D.C., and the integrated case management system – to track all PSC formal cases and proceedings.


Lisa Edwards


Dan Wells


Paul Frattini

Lisa Edwards, Paul Frattini, Joel McElrath, Dan Wells, Electric Power Research Institute

Observing similar applications in other industries, the SMART chemistry team designed, procured and constructed a group of instruments to demonstrate automated near-complete online monitoring of nuclear plant chemistry. This can replace manual collection and analysis of water chemistry and thereby reduce plant operating and maintenance costs.


Joel McElrath

Tilak Subrahmanian, Eversource

Historically, energy efficiency was approached one project at a time. As vice president for energy efficiency, he led the initiatives to scale it up and to move away from general rebate programs to more targeted approaches for different types of customers. And he led the collaboration with banks and credit unions to roll out financing mechanisms to encourage customer energy efficiency investments. See the interview of Subrahmanian and a colleague in the June 2019 issue of PUF, pages 18 – 24.


Tilak Subrahmanian


Luke Benedict

Luke Benedict, Exelon/PECO

On the smart grid distribution automation team, he created the PowerBI real time alerts dashboard which alerts a user if the amount of alarms for a specific device pass a set threshold. The goal is to improve the health of distribution grid equipment by detecting equipment damage and issues as they happen.

Dave Brett, Kathy McWilliams, Nick Mart, Exelon/PECO

This team addressed the need of customers, contractors and real estate agents to know if natural gas is readily available at a property, by developing the interactive natural gas availability map. A weighting is assigned which informs users on the likelihood of receiving natural gas at a reasonable cost.

Charles Vinsonhaler, Electric Power Research Institute

SOLVE is the first and only tool of its kind specifically designed for electric power companies to analyze the sustainability value of projects and programs. Vinsonhaler, the lead technical analyst in SOLVE's development, led the programming of its calculation capabilities, conceived of and created the heat map to visually identify opportunities for enhancing sustainability value, and co-leads discussions with companies to customize the tool. Eight electric power companies have implemented SOLVE. See the interview of Vinsonhaler later in this issue of PUF.


Leah Vogely

Leah Vogely, Exelon

She has been instrumental in bringing innovation to the company through design thinking. Examples are development of an Apple watch app, launch of the digital solar toolkit, and improvements in the sign-up and move journey for customers (that led to a hundred percent increase in online completion rates).


Charles Vinsonhaler

Bryan Uber, Keith Steger

Keith Steger, Bryan Uber, Jason Zola, Exelon/PECO

This revenue protection team developed a solution to address the challenges of illegal connections and electric theft. The patent pending solution – named Meter Defender – includes an Internet of Things sensor, a mobile app for field techs and a comprehensive reporting and management website. Meter Defender has discouraged electric theft with its quick response time of theft detection.

Steven Kalashian, Pooja Nayyar, Jessica Swansen, New York Power Authority

The team developed and implemented the Eureka! innovation competition in which a hundred and fifty eight proposals were submitted. Four winners resulted, including a global administrative manual, 3D digital modeling, an on-demand buoy (to locate junction plates on the Lake Erie floor for installing an ice boom), and small vertical wind turbines adaptable to lower wind speeds in challenging siting areas.

Debra Lam, Georgia Tech

Before moving to her position as managing director of smart cities and inclusive innovation at Georgia Tech, she served as Pittsburgh's first-ever chief of innovation and performance. In Pittsburgh, she developed the city's first strategic plan for innovation, called the inclusive innovation roadmap. (Lam participates in Dentons' Smart Cities & Communities Think Tank and was nominated by that firm.)

Evan Yager, New York Power Authority

His team created the utility operations project portfolio, providing a web-based structure to manage projects across the organization, with advanced data capture and analysis. The goal is to help transform NYPA to a digital utility requiring a complete overhaul of legacy systems, processes and culture.

Kimberly Gauntner, Steve Hughes, Yi Li, Matt Wallace, PPL Electric Utilities

With the support of a federal grant, the team is completing, by year end, a fully-integrated distribution energy management system with automated processes to tackle the challenges of accommodating high penetrations of distributed resources and improve customers' distributed resources experience. System capabilities include considering bi-directional fault detection from automated devices, hidden load values, and SCADA controlled inverters.

Patrick Barnett, Mychal Kistler, Ihab Salet, PPL Electric Utilities

The team integrated a vendor's high-impedance fault detection technology along with its own innovative method to de-energize downed electric distribution lines. During a windstorm in late February, the first successful operation of the new system was demonstrated, automatically powering off a line that came down in a remote wooded area. By the end of this year, the system will be in place in about fifteen hundred locations in the utility service territory, wherever there are protective relays. See the interview of Barnett, Kistler and Salet later in this issue of PUF.

Larry Bekkedahl, Portland General Electric

As vice president of grid architecture, integration and system operations, and previously as senior vice president for transmission services at Bonneville Power Administration, he is leading the way on deployment of the virtual power plant within the distribution system to enable integration of distributed energy resources at scale. Including a first-of-its-kind smart grid test bed focused on three key substations to engage customers, targeting unprecedented participation in demand response and smart home technologies of more than two-thirds of them – totaling over twenty thousand customers – in these three distinct communities.

Don Akau, Chris Arends, Carrie Bowers, Michael Deleo, Katie Giannecchini, Steve Vanderburg, San Diego Gas & Electric

Six employees from the meteorology and vegetation management groups collaborated to create a vegetation risk index, a sophisticated tool enabling the utility to identify high fire risk areas based on advanced analytics of historical data on trees, power outages, and weather conditions. The index now assigns a risk profile of normal, elevated, or extreme to every tree – for more than four hundred and sixty thousand specific tress – located near utility power lines in every circuit of the forty-one hundred square-mile service territory.

Bryan Hannegan, Holy Cross Energy

Formerly an associate laboratory director at the National Renewable Energy Laboratory, Hannegan is driving his utility in Colorado to seventy percent renewable energy with aggressive acquisitions of wind and solar generating capacity. And his utility will be the first to field-test algorithms developed by NREL to optimize and control distributed resources.

Lisa Hannaman, Jake Huttner, Nicole Irwin, Paul Kubasek, Christopher Malotte, Robin Meidhof, Eric Yamashita, Southern California Edison

Led by senior advisors Hannaman and Malotte, the clean energy optimization team designed a comprehensive meter-based greenhouse gas framework to encourage pilot customers like the University of California and California State University systems to undertake emission-reducing programs. The utility offers a choice of such programs and pays for emission reductions on actual metered results.

Nery Navarro Medrano, Bibhush Ranjit, Belinda Vivas, Southern California Edison

The team developed the integration capacity analysis tool, which is a customized user interface with advanced functions that let the public interact with trillions of records on a geospatial platform. The tool is already streamlining the interconnection process and supporting customer use of clean technologies by allowing users to view general locations of utility distribution circuits, substations and sub-transmission systems, distributed energy resources, and current, queued and total interconnections.

Ken Barnett, Adam Dunkerley, Symya Edwards, Chesley Hughes, Southern Company

This team created eTOPS, a process that digitizes construction turnover packages – that includes all documentation prepared during design and construction, to greatly reduce costs. As projects progress and design changes arise, turnover packages can rapidly grow, so digitizing the packages is important.


Julie Duncan, Emmanuel Ansah, Tim McCaffery, Sal Orsino, Lisa Garcia

Emmanuel Ansah, Will Barnes, Lauren Biernacki, Julie Duncan, Lisa Garcia, Sal Orsino, Jared Osorio, PSEG

The Alexa skill team developed, implemented and released a real-time customer service through the use of a natural language interface. After a one-time login into the Alexa app, customers are able to ask billing questions, make payments, report power outages for their home, check energy usage, and schedule service appointments for broken appliances, air conditioners and stoves. The team continues its work, extending to other devices and connecting to the meter data management system for usage data as frequent as fifteen-minute intervals. See the interview of the team later in this issue of PUF.

JoLynda Daugherty, Camille Holland, Wendell Ivey, Michelle Warrick, Southern Company

Ivey and his team saw that five different plants in Mississippi were processing invoices separately with the same documentation, past due, rate discrepancy, and vendor terms and condition issues. They streamlined and consolidated the processes with subject matter experts invoice reconcilers.

Morgan Henderson, Elizabeth Liveoak, Kevin Tate, Southern Company

Previously, when there were newly-submitted transmission service requests, the Open Access Same Time Information Systems and Operations Planning groups coordinated to determine the appropriate actions. This legacy process was inefficient, time-consuming, and prone to human performance issues. So the team developed a new web-based software system to improve and simplify transmission service requests workflow and provide a clear audit trail. The OAM Request Workflow tool now clearly communicates the status of all transmission service requests.

Cole Cremeen, Terry O'Malley, Randell Moore, Southern Company

Operators at a major plant of Mississippi Power noticed alarms and faults were being generated requiring connecting to the relay on-site issuing the alarm or fault. This team developed a new protection interface with advanced data to speed diagnosis and recovery from faults. The time it takes to fix issues when an alarm is triggered was up to three hours, but this has been reduced to just an hour.

Justin Schilling, Ross Wehner, Southern Company

During last winter, there were concerns about the ability to meet customer demand on a peak winter day. The team worked together to create the company's first-ever cross-commodity optimization deal – selling some natural gas assets from one region to another for greater value to pay for an additional five hundred and twenty megawatts of generating capacity – to enhance reliability and minimize customer cost during extreme cold.


Clifton Black

Clifton Black, Southern Company

As a principal engineer in the Power Delivery group, Dr. Black established the Schatz Grid Visualization and Analytics Center. It is intended to bridge the industrywide gap in the ability to demonstrate and evaluate new power grid technologies and enable solutions to be deployed quickly and configurations to be altered easily reducing research and development time and cost. The Center also fosters collaboration with the Electric Power Research Institute, U.S. Department of Energy national labs, academia and technology providers. See the interview of Dr. Black later in this issue of PUF.


Steve Baxley


Carl Jackson

Steve Baxley, Carl Jackson, Southern Company

Baxley and Jackson are providing innovative leadership and technical expertise for testing, development, and deployment of a diverse portfolio of energy storage technologies. They were instrumental in several breakthrough projects, including the Energy Storage Research Center in Birmingham, Alabama – a plug and play network for third-party innovators, the McCrary Battery Energy Storage Demonstration in Pensacola, Florida – for understanding the siting, installation, and operational requirements of commercial and industrial-scale energy storage systems, and the Alabama Power and Georgia Power Smart Neighborhoods in Birmingham, Alabama and Atlanta, Georgia.


Danny Kermode

Danny Kermode, Washington Utilities and Transportation Commission

Recognizing the growing gap between technology and the tools used for regulatory oversight, he became a leading advocate for the national initiative to move to structured data for collection and analysis of regulated utilities information. Structured data is a new tool that allows regulatory analysts to begin their work right away instead of spending considerable time inputting and correcting data. This has been adopted by FERC as a national standard for utility reporting in Order No. 859. See the article by Kermode in the October 2019 issue of PUF, pages 34 – 37.

Corey Capasso, Urbint

He led the development and deployment of UrbintLens for Damage Prevention at Southern Company. It's an artificial intelligence predictive model – cloud-based – allowing pipeline operators to determine the riskiest excavation activities so they can intervene to prevent pipeline damage. Additionally, the software provides insights into excavators that are likely not calling 811 before they dig.


Dave Sonntag

Phillip Schaeffer, Dave Sonntag, Western Farmers Electric Cooperative

Schaeffer and Sonntag are developing the largest co-located wind, solar and energy storage project in the nation, called the Skeleton Creek project. For co-op members in Oklahoma and New Mexico they'll see DC fast chargers every fifty miles throughout the service territory to spur adoption of electric vehicles.

John Deutsch, Jacob Ladenthin, Amy Black, Blake Stave, Toni Hauser, John Bell, Scott Camps, Joe Savage, Tanea Thompson

Lawrence Bick, Amy Black, Matthew Boehlke, Michael Ganley, Jeffrey Imsdahl, Mitchell Olson, Dawn Phillaya, Scott Siebert, Tanea Thompson, Chad Wollak, Xcel Energy

This team – from facility services, real estate services, business systems, security services, strategic sourcing, supply chain, and enterprise resilience groups – drove the development of the new enterprise command center, an integrated approach to enterprise-wide monitoring to improve the multi-state utility's ability to respond to and recover from any potential hazard that may impact customers, company assets, operations or reputation. The center integrates the security operations center, cyber defense center, IT operations center, network operations center, and other gas, electric, customer care, and nuclear functions. PUF

Profiles in Innovation

Conversations with Emmanuel Ansah, Will Barnes, Lauren Biernacki, Julie Duncan, Lisa Garcia, Sal Orsino, Jared Osorio, PSEG; Patrick Barnett, Mychal Kistler, Ihab Salet, PPL Electric Utilities; Clifton Black, Southern Company; Luiz Cheim, ABB; Kirk Ellison and Jeffery Preece of EPRI; Charles Vinsonhaler of EPRI; Kim Wagie, Arizona Public Service

Among the forty-six nominations from twenty-seven utilities and other organizations of a hundred and thirty-seven top innovators, we wanted to know, what makes someone a top innovator? Where did they come from in their organization? What caused them to dream up their innovation? And how do they plan to further build on this development?

So we chose a sample of the forty-six nominations, seven in all, and asked these questions. Their interviews follow. The seven nominations herein came in from six different organizations. Four utilities – APS, PPL, PSEG, Southern Co., one vendor, and two from EPRI. And include sixteen top innovators.

What makes a top innovator tick? Read on.

Team of Seven PSE&G Employees Nominated

PUF: Lisa, you're the product owner for the New Jersey part of PSE&G. Give an overview of this project and talk about the team.

Lisa Garcia: We've developed an Alexa skill for PSE&G. We started in April of 2018 and launched it in December. This was something that we wanted to be at the forefront for our customers, giving them another option to access their account, to pay their bill, and get their usage.

With voice assistants becoming more popular, we wanted to make sure that we would be there if our customers chose to do business within that channel. We released it last year and we've been building new features throughout the year.

You now have the ability to pay your bill through Alexa, get your usage, report an outage, and schedule service appointments, with or without our Worry Free appliance service coverage. You can also ask Alexa for things like savings or safety tips.

PUF: For PSEG Long Island, how do you work together?

Will Barnes: Since Alexa is an Amazon product, we adopted something similar to the way they operate as a team model. Even though we are individual product owners for New Jersey and Long Island, customers mostly have the same needs, though some specifically may differ, for example Long Island does not provide gas service or Worry Free service.

We worked collaboratively to come up with one Voice User Interface model so that we would be consistent on both ends, in New Jersey and Long Island. We had to work closely together to get the best of both worlds, and to get the product up and running.

PUF: There are two sides to the team working together. There's a technical side, then there's the business side.

Sal Orsino: Yes. A few years ago, Alexa started as my summer internship project. I was an intern, and we put together a demonstration of what Alexa could do. It was, what does PSE&G stand for? Where is its territory? Questions like that. That was summer of 2017.

Over the next few months, senior leadership was one of the biggest joggers for delivering a legitimate voice channel for our customers. They saw the value, and we put together a proof of concept. So, throughout February, March, and April of 2018 we were building out our basic functionalities like checking your electric usage, making payments, and checking your balance.

You now have the ability to pay your bill through Alexa, get your usage, report an outage, and schedule service appointments.

– Lisa Garcia

For the initial duration before our first go live, I was the main technical resource, doing all the development on the front end, and the back end for the skill. That led to my career.

PUF: Julie is also listed as a developer. Julie, are you working with Sal on this? When did you come in, and what do you do?

Julie Duncan: Yes. I started at the end of February of this year. I help Sal out with the development.

Sal Orsino: That's a bit of modest terminology. I have to give Julie the credit. She's taken our skill up to a new level over the last couple of months.

PUF: Emmanuel, you're the scrum master. What do you do?

Emmanuel Ansah: The scrum master is the facilitator for an agile development-product team. As the scrum master, I manage the interactions and collaborations between the business and development team so we can collectively achieve the goal for the project and product as a whole.

Additional roles that are included in this framework are the product owner and the development team. The product owner represents the business for the product and makes executive decisions in line with the product's vision. The development team is a self-organized team focused on executing these decisions and delivering working software for the product.

In the fashion of agile development, we have scrum ceremonies

The PSE&G Alexa Team from left, Julie Duncan, developer; Emmanuel Ansah, scrum master; Tim McCaffery, business analyst; Sal Orsino, developer; and Lisa Garcia, product owner.

People forget that you can open up your Alexa app and use the skill on your mobile phone – simply tell PSE&G that I have a power outage and that is all it takes to notify us.

– Julie Duncan

that are interactive and collaborative – one of the key activities we have is our daily standup call. This is no more than a fifteen-minute call where we have the development and business team provide a quick status of what activities are being worked on in line with achieving the sprint goal.

On the daily standup call, each team member shares progress of what was done on the previous day, what they will be working on for the current day and if there are any impediments blocking the team from achieving our collective goal. Impediments are then discussed among the team to resolve them. In instances where more discussions or other teams are required to resolve the impediments, we regroup on a separate call.

Another key component of the agile development approach is the sprint, which is a time-boxed period where we execute our development. The length of each sprint is decided by the team, but we typically release our features after three or four-week sprints. The functionalities we want to develop for any given sprint depends on the team's mutually agreed upon goals and priorities.

We meet at the start of every sprint in what is called a sprint planning meeting, where we decide what user stories, or requirements, we will pull off the product backlog, based on the team capacity and the duration of our sprint. The product owner provides final approval on the goals to start development. Midway in the sprint there are conversations reviewing features with IT and the business, then toward the end of the sprint we perform a sprint review.

The sprint review is a checkpoint to review everything that has been done in that sprint. To prepare for our next sprint planning meeting, we consider what the remaining open items are. These items are then put back into our product backlog, which is our living document full of user stories explaining the functionality we want to achieve.

PUF: What is the term, ceremonies?

Emmanuel Ansah: Ceremonies are required events that establish how development work is executed. The ceremonies are daily stand-up, sprint planning, sprint review/demo, and sprint retrospective. The sprint retrospective culminates all the activities for the sprint, and this is conducted at the end of each sprint. During the sprint retrospective meeting we review what we did well, what we didn't do well, and then how best we can incorporate improvements to make our next sprint better.

PUF: Lauren, you're the business analyst?

Lauren Biernacki: Yes. I'm an engineer from gas operations. When the project started, senior leadership had a vision to include appliance service appointments in the skill. The feature would allow customers to schedule service appointments with our field technicians. My role on the team was to be a liaison between the Alexa team and the technicians in field operations for the appliance service appointments.

PUF: Jared, what's your role?

Jared Osorio: Regarding the Alexa product, I wasn't in the people team. Lisa's on my team and we focus on digital customer experience. In our portfolio we have the Alexa skill, mobile app, a texting communication program, outage maps, and a My Account customer website.

That's all of the ways customers can interact with us digitally, and through self-service. That's something we're looking at holistically. When we heard about Sal and his project and we saw the initiative, we wanted to be a part of it.

We understand that this medium has the growth potential, the

same way as mobile fifteen years ago, before the iPhone perhaps. We see the asset of visual aids and how important technology is going to excel exponentially once it reaches its tipping point.

We want to be there and be in the channel for customers when it becomes viable. Potentially, it could shift most of our customer interactions from a screen through a speaker or a headset. We want to give it as much attention and design as possible. We want to make it a good user experience.

PSE&G has a wide diversity of customers. You have folks in their twenties, single in an apartment, versus older people and they're probably not using Alexa. How do you deal with people having different needs and maybe are confused by technology? Some people are good with it, but others are not.

Granted you've got smarter companies like Facebook and Google that serve everybody well. But, it's challenging. So, we try to look at some of the target demographics of the skill and make sure we're in line from that perspective.

We have a mantra. We don't want to over complicate things. We have complex products. We understand that people don't often understand what they're buying from us and we try to break it down as simply as possible so we can relate to customers.

PUF: Since the focus here for top innovators is what's cutting edge and creative, what was the most creative part you were involved in?

Lisa Garcia: The most creative aspect of the project so far was building our service appointments within the skill. It was complex because there are a number of different appliances that we service, and some have different scenarios that we had to capture. We had to make sure that we covered everything and did it in a way where a customer would be speaking to the device as if they were speaking to a human.

We wanted to make that as seamless as possible and not long winded, with a lot of questions. We really had to put ourselves in the customer's shoes to see how they would say things.

Will Barnes: To Lisa's point trying to have Alexa give you this personal experience, we wanted to try to emulate a conversation with a representative and it's two-fold. One, we could avoid that phone call to a customer service rep, which opens up our lines to answer calls quickly. It's also giving that experience to customers.

They want to ask their questions freely and not have to press one, or have the voice assistants say, sorry, what was that? It can simplify that. One of the ways we did that was not something we promote on our website.

But we built a little piece into Alexa, which is, why is my bill so high? It's a common question that we've gotten through the call center. This is something Alexa can help with if anybody asked.

She would be able to respond with; it looks like the temperature was higher this month than paid the same time last year. It's probably the little tips to a customer to hint as to why it's possible the bill was higher and in some cases to even say, your bill is the same as the same time last year, because some customers may forget that.

PUF: Sal and Julie, what did you see that seems like it was cutting edge or creative?

Sal Orsino: One of the more creative things that we've gotten to do is not live yet, but it's part of our overall vision down the line. That's connecting to smart appliances in your home.

We have a proof of concept developed internally where we can connect to smart devices such as a Nest thermostat. For example, following what Will said, you might ask, why's my bill so high this month?

We can say, well now it's only seventy degrees outside but you have your air conditioner on sixty-eight. You should turn off your air conditioner and open your windows. Would you like me to turn off your thermostat?

> **We have a proof of concept developed internally where we can connect to smart devices such as a Nest thermostat.**
>
> *– Sal Orsino*

Those thermostats generally have economical settings that we can connect to. That's part of our bigger vision, being able to suggest something, and act for you as well. That's being fully integrated into your smart home.

PUF: Julie, you've been in for less than a year, but are you in on that too? Is that something that's fun to work on?

Julie Duncan: Definitely. One of the features that we look forward to watching customers use is reporting power outages, which everybody experiences. When we were developing this, we heard the question, how are we supposed to report an outage through Alexa if you're out of power?

A lot of people forget that you can open up your Alexa app and use the skill on your mobile phone – simply tell PSE&G that I have a power outage and that is all it takes to notify us. It's one other way to notify us that the power's out.

PUF: Lauren and then Jared, was there something that you saw as creative?

Lauren Biernacki: With Alexa, we built so many tiny nuances throughout the skill that one person might experience, but not everyone will. For example, if someone says, I smell gas. Alexa tells the user, you should leave the house, go at least three hundred and fifty feet away, and call PSE&G and then automatically shuts down so that you can't use her anymore because you shouldn't be using any electronics.

Jared Osorio: With this team in particular, it's all the things they mentioned. For the thermostat, the gas usage, and certain

departments, those are incredibly innovative. I liked the way the team approached it because great companies, and great design, is about fitting into your customer's lives.

That's what Alexa is. It's the beginning piece. All the things that you just heard were how we can add value into those little moments of your life. The team took hold of that.

We developed a platform that customers are enjoying. We can easily take that and switch to a Google platform, or Siri if that becomes the next digital advance, because we've got a framework.

We want to give it as much attention and design as possible. We want to make it a good user experience.

– Jared Osorio

Our ability to have that knowledge in house and then position ourselves and pivot when needed is going to be tremendous. ❍

Mychal Kistler, Patrick Barnett, Ihab Salet, PPL Electric Utilities

PUF: What do you do with PPL and what do you do together as part of this team?

Mychal Kistler: I spent my first year at PPL doing transmission modeling and I've spent the past twelve years doing protection, mostly distribution, and some transmission. But I've branched out into a lot of other work, working on standards, relay testing, and things like that.

Patrick Barnett: I've been here about four years. Most of my background is in our relays on the distribution system, specifically all the pole-top equipment. I'm in our distribution protection organization with Mychal and I'm leading the deployment piece of this technology.

Ihab Salet: I've been with the company for five years. I started with PPL Electric Utilities automation and then I went into the field as a relay test engineer. After that I went into our operations department and spent some time there as an engineer and then as a shift supervisor.

Now I supervise our protection and control group and I have been here for six months.

PUF: How did this group come about?

Mychal Kistler: PPL began deploying large amounts of Schweitzer Electric Laboratories relays on its distribution system around 2014. SEL's Arc Sense technology was in the relays, but at the time we weren't utilizing it. We and management thought we should try to use it. We investigated it a bit and ended up turning it on to see the results. That was the beginning.

PUF: What is Arc Sense?

Mychal Kistler: Arc Sense is a proprietary algorithm that SEL came up with around 2001. It's been around a long time. It looks at the harmonic current of the line and trends it over a twenty-four-hour period. It tries to filter out harmonic load and then it looks for deviations from those harmonics to count what arcing signatures look like.

PUF: How's that useful if there's a problem in a line, with this kind of equipment? Can it say, well normally this line looks like this, but something weird is happening.

When you consider that the utility industry has been around over 100 years and there's no solution to this problem, coming up with something, even if it's not 100 percent, is rewarding.

– Mychal Kistler

Mychal Kistler: That's how it works. Now if you date back to Electrical Engineering 101 days, remember that current is just voltage divided by impedance. When you have a wire on the ground, it draws very little current, so there's no electrical quantity we can use.

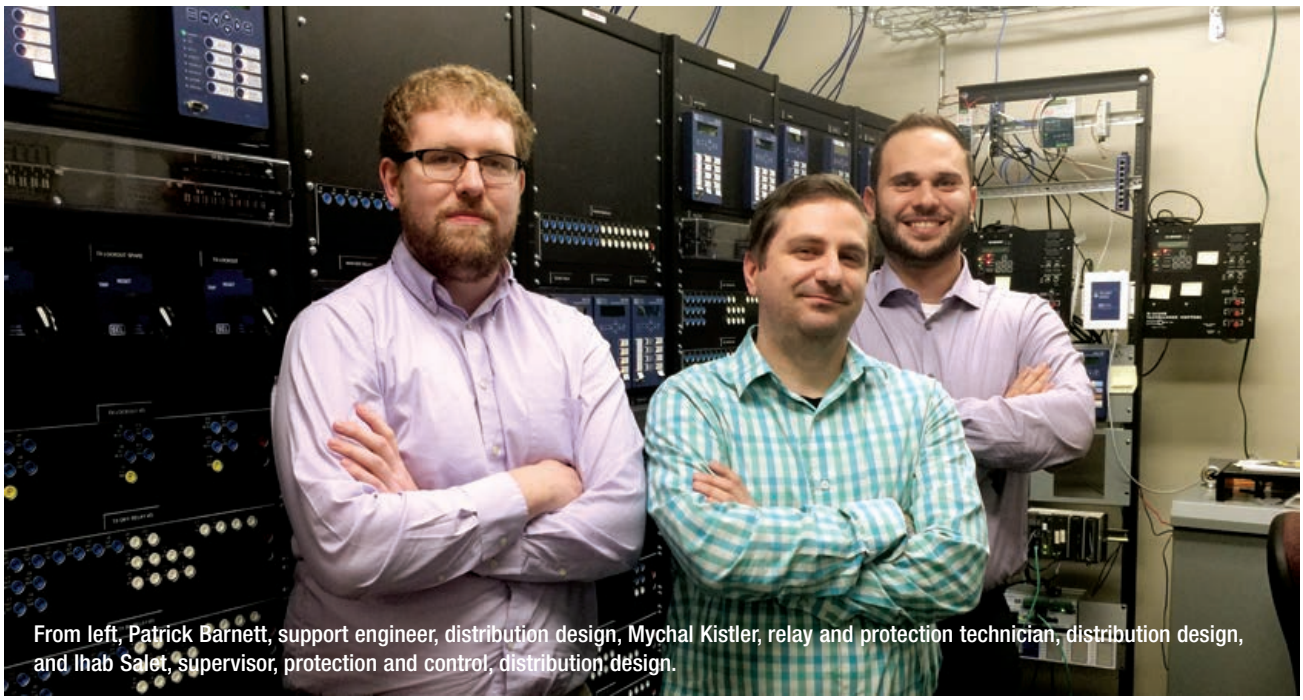
Traditionally a utility's method to find these low-current faults was to use ground relays looking at line balance, but it's not always accurate. This was technology targeted to look specifically for down conductors.

SEL originally tested it in Texas with a utility. They did ten tests to come up with what a downed conductor signature looked like. Then a couple of years ago we did tests in Massachusetts, completing sixteen tests confirming SEL's initial results.

Patrick Barnett: I helped Mychal out in those initial years in terms of some of the testing we did internally with the logical algorithm we have on top of SEL's Arc Sense technology.

We built logic into our relays to interpret what the SEL Arc Sense algorithm was doing and are using that to safely and automatically isolate downed conductors.

It's automatically taking them off our system. Mychal was involved at the forefront with a lot of the testing and



From left, Patrick Barnett, support engineer, distribution design, Mychal Kistler, relay and protection technician, distribution design, and Ihab Salet, supervisor, protection and control, distribution design.

understanding of how Arc Sense was working. Then I got involved with Mychal when it got to the point where we needed to add logic to the relay. We had to make the relay as secure as possible.

PUF: Ihab, what was your piece of this?

Ihab Salet: All the credit goes to them. I came in at the time where we were trying to deploy it. I wasn't involved with developing the algorithm, but I helped facilitate deployment.

PUF: Tell me about that deployment because this is not just theoretical, right? You have it out in the field in Pennsylvania.

Patrick Barnett: One thing unique about the PPL system, and maybe it's not unique to the entire country, is the way our old metering infrastructure worked. At PPL, this is something we learned as we started doing the testing.

The way we read the meters was through a technology utilizing power line carrier. We'd inject harmonics at the substation onto the line to read back meter information from our customers.

By injecting harmonics onto the line, we were giving the SEL Arc Sense technology exactly what it was looking for, disturbances in the harmonics. We learned this up front and PPL is now at the point where we are replacing that older infrastructure with more advanced meters allowing us to take full use of the Arc Sense technology.

As we are decommissioning the old meter equipment off our system, we are also turning on the tripping piece of our algorithm in the relays. PPL has about one thousand three hundred feeders and we currently have the technology deployed in about fifty percent of our devices.

PUF: If there's a storm, or a car hits a pole, it comes down, and what happens? Walk us through that.

Patrick Barnett: I don't want to go too much into the details

We built logic into our relays to interpret what the SEL Arc Sense algorithm was doing and are using that to safely and automatically isolate downed conductors.

– Patrick Barnett

of our logic coupled with the Arc Sense technology working inside the relay. But essentially, if someone drives into a pole, or a storm knocks wires down onto the ground, traditionally on the system, depending where that conductor lands and what it comes in contact with will change how much short circuit current is available at that specific fault location.

So, we might only draw ten amps from our substation breaker all the way out to that wire lying in the grass. The current in that scenario is not enough to trip the breaker via traditional methods. Most utilities in the country, at least on the distribution system, are looking for high amounts of current to trip their devices, and a downed conductor draws a very low amount.

But what a down conductor does do is typically you'll find arcing or sparking. You could find videos online of downed wires in the grass and you'll see that behavior.

While that's not a lot of current, it is a certain signature in terms of the harmonic current on the line. That is what the SEL technology, the Arc Sense that they have inside their relays, is looking for. Then our piece is on top of it is saying, okay, under these certain scenarios, treat that as a down conductor and operate the upstream device.

PUF: Why is this a good project and what was most rewarding for you in working on this?

Ihab Salet: The most important aspect of the whole technology is safety. If you get a downed wire, you know the wire is hot or energized. If anybody gets close to it and touches it, that can be fatal.

Mychal Kistler: There are two aspects of that. Safety is the most important. Then, when you consider that the utility industry has been around over one hundred years and there's no solution to this problem, coming up with something, even if it's not one hundred percent, is rewarding.

Anything's better than zero. We put a lot of engineering effort into this and I was able to do things I've never done before. One was facilitating the test with seven thousand two hundred volt energized conductors on the ground. Figuring out how to do that was a good challenge.

Patrick Barnett: Safety is the main driver. But what makes this rewarding requires a story. Once we began enabling the tripping piece in our relays, the very first time it operated on our system it de-energized a section of line where we had a report from a customer claiming that there was a small fire from a downed wire and her husband was trying to put it out with rubber boots.

The most important aspect of the technology is safety. If you get a downed wire, you know the wire is hot or energized. If anybody gets close to it and touches it, that can be fatal.

– Ihab Salet

Whether that customer report was accurate or not, we successfully de-energized the line in a scenario where it normally wouldn't have been de-energized. The impact of potentially saving somebody's life is huge. ❍

Clifton Black, Principal Engineer, Research and Development, Southern Company

PUF: Talk about your role at Southern Company.

Clifton Black: I'm a principal engineer for Southern Company Research and Development. This organization is part of Southern Company Services. We are a shared services entity under the Southern Company umbrella, which means our work supports all the operating companies.

I focus on power delivery research and development; particularly grid operations, planning, analytics, visualization, and related topics.

PUF: There's something called the Schatz Grid Visualization and Analytics Center. Talk about that.

Clifton Black: That is the name of the new center established in April of this year. This center is an innovation environment, which allows us to develop, evaluate, and demonstrate next-generation situational awareness technologies for transmission and distribution.

The core of what we do is take real-time data from the power grid, similar to what is used in a control center, but instead of using data to operate the grid, we leverage data for research purposes. We have significant modeling and simulation capabilities including a real-time digital simulator with hardware-in-the-loop functionality. But it is the infrastructure to leverage real-world data for research that sets what we're doing apart from what others in the industry are doing.

Visualization is a critical component of situational awareness that often does not get the focus and attention it deserves.

Because agility and speed are significant merits in the evaluation of new technologies, the state-of-the-art center will enable solutions to be deployed quickly and configurations to be altered easily, reducing time and cost in R&D. Another important aspect of our research is around technologies and functionalities for the control center of the future.

PUF: You had a major role in establishing the center. Also, there's a lot of work around the country on more sensors, more data and using analytics, and various sources of artificial intelligence to use this data for operations. But you're saying, how can we use this data for research?

Clifton Black: Sure, let me address both items. One is the name of the center, the Schatz Grid Visualization and Analytics Center. It is named after Joe Schatz, the former power delivery R&D manager. Joe passed away last year, and we dedicated the center in his memory.

A few years ago, I was working with one of the national labs

on a new algorithm to use both SCADA data and synchrophasor data to assess grid stability. I shared the project idea with the Operations group. They were excited about it but were in the process of replacing our energy management system, so they were unable to provide the support that I needed at that time.

Scenarios like that helped me realize we needed an environment where we could get actual real-time data from the grid for research but not unduly impact the folks who operate the grid. I shared the concept for the center with Joe, and he asked me to put a proposal together, so I did.

He was my manager then, and he was behind it all the way. We wouldn't be here without his support, and his backing. As I talked with different people in management to get buy-in, Joe was always there helping push the vision. It's quite fitting we named the center in his honor.

Regarding the second item about the use of data – you are correct. There is a lot of work going on around the country on sensors, data analytics, and artificial intelligence for operations. We, however, use the data for research. We are working on developing and evaluating new analytics and artificial intelligence tools to generate new insights for improved decision support. Our environment is pre-production. Once new tools are validated and deemed valuable, we can work with business units to move them into operations.

PUF: There are interesting aspects to the name. Why was Grid Visualization included?

Clifton Black: Visualization is a critical component of situational awareness that often does not get the focus and attention it deserves. The focus on visualization, going back to the name, has to do with the idea that when you get ready to share information with people who need to understand and use it, you must think through the most intuitive mechanisms to do so.

Visualization is not simply having a screen for display. Visualization is a science around the human-machine interface. How should we provide information to the intended audience in support of their goals? We must think about it from their point of view as users, as opposed to only from the point of view of the designer.

Situational awareness has to do with asking and answering three questions: What? So what? And now what? If something happens on the grid, can you use data to detect and understand what happened, understand the implication of what has happened and generate a plan to effectively deal with what has happened? These questions may be applied to all aspects of the grid including security, reliability and resiliency.

We want to develop technologies that can span a wide domain for the power grid and ask, can we develop the analytics leveraging data from a variety of sources in new ways, to inform decisions and support information to a variety of stakeholders? Well thought out visualization tools play an important role in this ecosystem.

Phasor measurement units, or PMUs, typically stream data at 30 times per second, over 100 times faster than conventional SCADA technology.

PUF: Talk about what you were doing in past years before you founded the Schatz Center.

Clifton Black: I'm coming up on my fourteenth year with the company. Southern Company is a fun place to work and I've always had great support from our management team. We are blessed to have a dedicated research and development group here at Southern Company.

After completing my PhD in Electrical Engineering at the University of Alabama, I joined Southern Company's research team. For some time, I have been responsible for a comprehensive research program focusing on electric utility grid operations, planning, analytics, and visualization. I lead internal research efforts across Southern Company's four regulated electric operating subsidiaries and manage industrywide collaborative partnerships with EPRI and other external organizations.

Also, previously, I managed the energy storage program. We gained insights about various energy storage technologies and shared information with internal teams interested in better understanding and deploying the technology.

The highlight of that work was the deployment of a one-megawatt, two-megawatt hour lithium-ion battery energy storage system in Cedartown, Georgia. This was a significant milestone.

We set it up to assess the battery system integration and interaction with a co-located, one-megawatt photovoltaic facility. Along with PV integration, we assessed peak shaving and reactive power support.

I also lead our synchrophasor program and have for several years. Synchrophasors are precise, high speed grid measurements from monitoring devices called phasor measurement units. PMUs typically stream data at thirty times per second, over one hundred times faster than conventional SCADA technology.

Each measurement is time-stamped using GPS, allowing measurements from different locations to be time-aligned. You see a much higher resolution of what's happening on the grid, which is especially helpful when conditions change quickly. The Northeast blackout in 2003 was a big driver for the widespread deployment of the technology.

When I got the program, we had about four PMUs across the company. By the end of this year, we will have one hundred and sixty PMUs installed. We have also developed a robust infrastructure and evaluated applications to leverage synchrophasors for business value including research supported by multiple DOE awards. ❍

Luiz Cheim, ABB

PUF: You are at ABB in the power grids division, transformers business line. What's your job at ABB?

Luiz Cheim: I am a senior principal R&D engineer in the North American Technology Center within the transformer business line. I work closely with the transformer components and services (TCS) product group and digital R&D team. Power grids transformers has several product groups that are also in charge of new product introductions, defining design, and production rules of new transformers as well as transformer components such as bushings, on load tap changers, and so forth.

TCS is in charge of parts, and after sales providing service, repair, re-manufacturing of transformers, site tests, site investigations of problems, and internal inspections. All of that has been performed by the TCS organization.

My work has been in the development of new methodologies for assessing the condition of transformers, analytics, software for fleet wide assessment, and other applications. I have also worked in the development of online sensors for the measurement of transformer operational parameters.

PUF: Measuring all of that manually was time consuming and costly, right?

Luiz Cheim: Manual measurements can be extremely time consuming and expensive. I have spent a good portion of my career on the development of new technologies to support improvements in this area. These include new algorithms, new methods, and new transformer components. The robot was one idea I had around 2011 while I was on site, at a large substation, helping some ABB colleagues with assessment of the condition of some key transformers.

Their work was to perform an internal inspection of a couple of large units. This is a common practice in the industry to assess the condition or the operational risk of a given transformer, when there is a significant indication that something is wrong. Such procedure happens hundreds of times a year around the world.

The robot for our application had to be a special robot. That's why it took us over four years to come to the final prototype.

Let me explain what I saw that day.

The person doing the actual internal inspection in one transformer was a soon to retire colleague.

The conditions were bad. It was a hot and humid day. Thousands of gallons of mineral oil had already been drained out of the transformer and stored away.

The so-called inspection window of a few square feet was open at the top cover of the transformer and a ladder inserted from the top allowed the human inspector to get inside of a dark, tight, humid and confined space.

I came to see my colleague and he was tired and hardly breathing. The inspection is a dirty job. I said I am so sorry you're going through that. He said no, this is my job.

That scene was my whole inspiration. In my opinion that is how inventions take place. There is always some coincidence or some sort of insight. Then I said to myself: this procedure is inhuman. We shouldn't be doing it this way.

PUF: So, you created, with probably others, an inspection robot. Give us a sense of what it does and what it looks like.

Luiz Cheim: I was just telling you this story of how normal inspections were done and still are today, around the world. In every country, most manufacturers and users do this to help customers to understand what is going on with their transformers. But there are several problems with such a conventional inspection.

Let's go back to the problem that the robot is solving, and why it is important. First you need to disconnect the transformer

from the grid to stop serving load, then you have to send people to physically disconnect the transformer, bring a tank truck near the unit and connect a huge hose between the transformer drain valve and the truck to pump the mineral oil, which is several thousand gallons, and store it there until the inspection is finished.

After draining, maintenance personnel can then climb on the cover and open the inspection window, which is normally wide enough to allow a slim body through. That is the beginning. The human inspector then prepares to get inside with special clothes, a mask and sometimes an oxygen canister to help breathe, given that the inside is still wet and full of petrol fumes. The inspector has to climb through the window, around the windings and supporting structures in a dark and wet environment, in a confined environment.

The working conditions are bad. This guy that we're sending inside needs to understand transformers. He needs to understand what is going on and what he is looking for, such as the places to look and take good quality and meaningful pictures. The guy has to be a hero.

Later on, when the human inspector writes his report, those pictures will be analyzed by experts. That will include designers and people that understand the transformer inside and out. These are the ones that will then say if the transformer needs to be repaired, if it can remain in operation or not.

In 15 to 20 years, in my opinion, nobody will do transformer inspections with humans.

Then a decision is made. Let's say, the decision was let's close the transformer, pump the oil back, and eventually, bring it back into operation because it is not a serious problem. It can, perhaps, wait a couple of years, depending on the problem.

The oil, however, is an important component of the transformer. It serves two objectives. One is that it's part of the electrical insulation of the transformer. The other objective is to remove heat from the windings. We want a good quality oil. The oil cannot be contaminated.

It must be in good shape without bubbles, particles, and foreign material. So, you have to treat the oil. You have to process the oil before you move it back from the truck to the transformer again. It's a time consuming and expensive operation.

We know that oil companies use robots undersea, sometimes with arms to do actual repairs. So, I thought, why can't we send something inside the transformer and have this machine do the inspection for us? There are so many benefits. For example, you don't need to remove the oil.

On my way home, from that site inspection, I realized that if we kept the oil inside the transformer, we don't need to process the oil to remove particles that may contaminate it. So, keep the oil there and let's send a machine inside with the oil, so if you navigate there, that thing will dive and hopefully find the problem for us.

The third advantage, if we are successful, is that the whole procedure can be done in a few hours, instead of days. So, the customer will have the transformer back in operation in a matter of hours, not days, as is typically the case with human inspection. The advantages are huge, including the cost savings.

PUF: How was it developed? Is it being used at a few places? Is its use growing?

Luiz Cheim: I know there is a huge interest. Here's how it was finally built.

ABB has a robotics group, which is in another division, and is not directly associated with transformers. I came up with the idea of the transformer inspection robot and helped in the spec

to support the development but the group that carried out the development of the final product was our robotics team.

At ABB we have a database for innovations. Whenever we have a new idea, an invention, that may be patented in the future or turned into a new product or even improve an existing product, we must explicitly describe it there, the concept, the purpose, the problem that it solves, etc. That was the challenge I faced. How to describe something that had never been done before.

I built the concept from scratch in order to convert the idea into a product. I explored the concept of a saucer-shaped three hundred and sixty-degree still camera, which is UFO-like or similar that could navigate inside of a power transformer, like a submarine. Remember that size is of the essence. Internal spaces are tight and a big challenge for navigation.

But it had to be controlled from the outside. I thought of the videogame joystick and imagined it in the hands of an operating person who has a camera where the images of the inside of the transformer can be seen. Then came the idea of the product needing lights because the insulating oil inside the tank may sometimes be dark. I put all the pieces together into the final proposal for our ABB innovation database and that's how it started. A project was initiated, and we joined forces with our robotics team.

It took us four years to get the first good images from the inside of a real transformer. That was our first prototype. Different from the oil industry, for example, you cannot take something that navigates in liquids and put it inside a power transformer because a transformer operates at high voltages. So, you have high electric fields. When you put this robot inside the transformer, when it dives, you do not want this device to contaminate the equipment.

Second, you don't want these robots to interact with the materials, such as the insulating mineral oil. You don't want it to destroy the solid insulation of the transformer. You don't want it to peel off and leave behind microparticles inside the transformer.

Third, the navigation is controlled from the outside. But you don't want the propellers to generate bubbles. For transformers, bubbles may be catastrophic because when you put it back in operation, if you have bubbles in the oil and they are near the high voltage side of the transformer, you may destroy the whole machine because you are affecting the dielectric strength of the oil.

All of that required a lot of development. Robots are common. There are robots that work underwater. But the robot for our application had to be a special robot.

That's why it took us over four years to come to the final prototype.

PUF: What was the most rewarding aspect for you in accomplishing this?

That was the challenge I faced. How to describe something that had never been done before.

Luiz Cheim: I've been around, with over thirty years of experience in this field. The most rewarding aspect was to have it developed as a product by ABB, from concept to the final product, involving two units that are completely different – power transformers and robotics.

We, the NAM Technology Center transformers team, generated the idea and provided the know-how that guided the robotics team in the development process of the product. But it was special in a way because it addressed a challenging problem with a novel solution.

Is it a huge advancement? I don't know. But in fifteen to twenty years, in my opinion, nobody will do transformer inspections with humans. They'll always be robotic and automated. So, to me this was a big realization as an engineer, as a research and development specialist, and as a scientist as well. ❍

Kirk Ellison and Jeffery Preece, EPRI

PUF: Give us a layman's idea of what this is that you have and are developing further.

Kirk Ellison: As an industry we see a need for new water management technologies. We see a whole category of technologies that are meant to eliminate having a wastewater discharge. These technologies include reverse osmosis and thermal evaporator systems. But to go along with all of those technologies, in addition to the treated clean stream of water that can be discharged or reused, there's also a concentrated liquid waste stream that needs to be disposed of.

This is an issue the industry been dealing with. One aspect gaining traction is what we call wastewater encapsulation. The primary driver at coal plants is that they find a way to dispose of concentrated liquid wastes, so they don't pose any future challenges and are permanently sequestered in a disposal unit, like a landfill.

That's been the primary area we've been working, looking at a lot of issues from fundamental chemistry, where we're looking at mixing these liquids with ashes and then specialized additives so that we achieve chemical stabilization and physical solidification of the material.

Concurrently, we're also working at the other end of the spectrum, by performing field demonstrations on the overall process and landfill management aspects of the material.

PUF: How do you go about this?

Kirk Ellison: We have internal lab capabilities where we do a lot of concrete like testing. We do a lot of mix design work, but we also have what I call our research partners or remote and even virtual labs.

We use these labs to send materials off for specialized testing looking at detailed mineralogy, and environmental properties. We also do virtual lab work where we do a lot of geochemical modeling.

PUF: Are these mostly EPRI projects where you've got four or five utilities working with you? How did that come about?

Jeffery Preece: Five utilities have been supportive and engaged since the initiation of the effort at EPRI. As Kirk mentioned, the genesis of this work stems from the need for alternative water management strategies. That's because a lot of technologies, while they produce clean water for various applications or discharge, do not address the long-term fate of constituents.

When we presented this idea to the EPRI membership, we were able to leverage their experiences with the water treatment technologies and an understanding of what they believe would be some of the long-term goals for applying this type of technology.

They've been very engaged in the research and have been active participants. They provide us with samples of ash and water that we can use to help them understand the technology. We use the information to build databases and frameworks for managing different types of wastewaters and additives that might be site-specific and then help them understand how the technology could be deployed in the future.

We have a number of ways that we conduct the research. It might be in our lab in Charlotte at a field pilot demonstration at the Water Research Center, which is co-located at Georgia Power's Plant Bowen. We also worked at a member's site where Kirk and the team performed the first large-scale field demonstration of encapsulation.

PUF: Give me a sense of why this is good for the environment and the companies.

Jeffery Preece: One of the biggest challenges we see is the long-term impact that a lot of these constituents could have. What we're trying to do is close the loop on the cycling and retreatment of some of these constituents.

When we think about where these constituents move around from air pollution to water and now to a landfill, we're trying to get these materials into a state where they no longer require active management.

The ideal end result would be that once this material is encapsulated and in position in a landfill, then the residual impact is diminished significantly if not to zero. We're trying to reduce the impacts of wastewater and pollutants over the next hundred years.

PUF: How did this come about?

Jeffery Preece: Kirk gave you information about where the technology ideas generated over the last couple of years. When I first started at EPRI, I was responsible for evaluating water treatment challenges and planning our future research portfolio.

Encapsulation is a springboard for more research and continuing to dive deeper on other application spaces.

– Kirk Ellison

One of the areas that our membership expressed concern about in 2014 was addressing solid waste management. It was unclear whether some of the liquid and solid wastes could be managed with existing practices.

When we evaluated it, we realized, we know water treatment. But we don't know a lot about our solid waste components, and we've not seen this as an industry.

When Kirk came on board we got this effort going and brought his experience and expertise into the research. Then we started to think, okay, if we're trying to encapsulate this material, we know we have to understand what the material is; but we also have to know the strategies around doing the encapsulation, and what that means for a power plant moving into the future. While there are some examples, both historically and in other industries, nothing was exactly the same.

Kirk Ellison: As the power industry started looking at discharge elimination technologies, very little was being discussed or considered around managing the residual wastes, other than saying this material has to go to disposal.

That was an initial driver. But the idea didn't just come from nowhere. There was a lot of work done in the initial phases of surveying what else was out there outside of the power industry.

We didn't see anything that was an exact fit technology ready to go off the shelf. But we started to see and piece together the puzzle with different ideas coming from multiple industries. Jeffery and I started looking at ways we could collaborate with those other industries and pull these ideas together.

We saw things being done like nuclear salt waste management and then also in the mining industry with cemented mine backfill and tailings disposal. There were a bunch of areas we were able to start pulling expertise from and build a consortium of folks to start working in this research area.

PUF: With the participating five companies, where does this go?

Kirk Ellison: As the technology is coming to the forefront and becoming mature, the potential applications basis is continuing to grow as utilities start to look at hosts of different wastewaters they may need to manage.

They are starting to ask whether encapsulation may be a fit for a whole host of different wastewater that are very site specific? We see the application space growing.

Encapsulation is a part of that picture for some sites, but it's a broader conversation. We see it being a springboard for more research and continuing to dive deeper on other application spaces.

Essentially the focus now is how can we assist with direct application of the technology? What does it look like to put this in full scale considering site specific conditions? There's a lot going on.

Beyond our lab R&D and piloting, we're look at equipment, systems integration, automation.

We are also trying to continue with our collaborative research model. Just as we brought aspects of the technology together from external applications, we are now asking ourselves can we take the technology and look at some examples where the mining industry or oil and gas or others could essentially leverage the chemistry and the fundamentals of encapsulation we have learned to solve some of their challenges as well? ❍

The ideal end result would be that once this material is encapsulated and in position in a landfill, then the residual impact is diminished significantly if not to zero.

– Jeffery Preece

Charles Vinsonhaler, EPRI

PUF: Why is this SOLVE tool important for the industry and the customer?

Charles Vinsonhaler: We initiated this research because we were hearing from stakeholders and utilities that they needed a better understanding of sustainability value. They were looking at investments and knew that the investments are producing sustainability value but weren't able to articulate that value and weren't able to analyze that value on a consistent basis.

There was an ask from our members in Program 198, our Strategic Sustainability Science program, to develop resources that would allow them to better understand sustainability value, and in turn allow them to make more informed investments, so that as they made every-day investments in their generation, in systems, in grid operations, they could ensure that those investments had a sustainability component and were ultimately informed by strategic sustainability goals.

We started with a literature review where we analyzed existing sustainability ROI methodologies. We looked at twenty methodologies across private sector, consulting, and academia. One of the findings is that we didn't identify any methodologies specific to utilities. We knew we were creating a novel product.

We identified themes. We used the themes and their approaches

to sustainability value to develop a visual framework so we could better articulate what we were capturing. We see this framework as a way to educate internal and external stakeholders about sustainability moving forward. From there we produced the SOLVE tool.

PUF: What's the value of clean air or water or other sustainability values that a project might have? That's always been difficult. How do you do that?

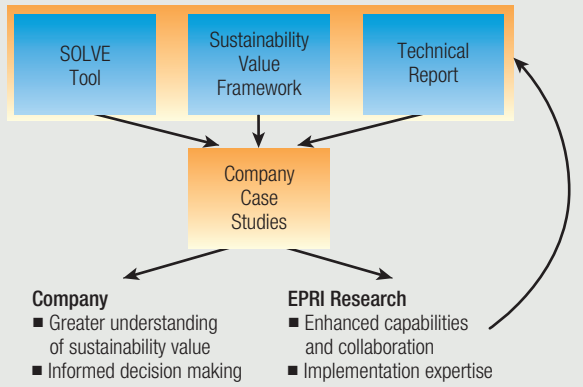
Charles Vinsonhaler: It is difficult, and we have seen in the past that government agencies and public actors have attempted to calculate these benefits. You hit on some of the key ones like clean air and water, because these are the ecosystem services we take for granted.

What we focused on with this tool is not providing coefficients. We weren't thinking about providing the value for clean air or a gallon of clean water because we recognize that value changes over space and time. The value of a gallon of water in Los Angeles is much different from the value of a gallon of water in Michigan.

Our goal wasn't to develop coefficients. It was to develop a process that would allow a company to consistently perform a project analysis. Value is specific to a utility. A company thinks about sustainability value from an internal perspective. What do we as a company need to do to be a better business, and from an external perspective, what are our stakeholders expecting from us?

FIG. 1 SUSTAINABILITY VALUE RESEARCH

SOLVE tool implementation:



The way the tool calculates value is specific to a company. It starts off by asking the company to calibrate the tool by identifying and prioritizing the sustainability issues that are most important, and then analyze the project through that lens of those issues. That way, what the tool ultimately produces is a quantitative number, but it's informed by the qualitative perspective of that company.

PUF: If I have a project, and I run it through SOLVE, what does the output look like?

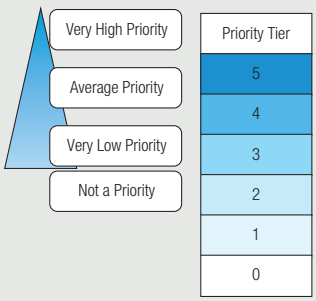
FIG. 2 SOLVE TOOL IMPLEMENTATION

Sustainability Value Research
SOLVE Tool Implementation

Set Company Priorities
What issues are most important to sustainability at your company?

Estimate Project Impacts
How will this project impact those issues?

Develop Project Strategy
How can my company maximize sustainability value?



Dimension of Value	Project Score					
Affordability	4	Energy affordability -9	Waste 56	Community vitality -36		
Brand Value	-23	Safety & health 20	Public policy relations 12	Air emissions -100		
Cost	8	Supply chain 42	Climate change -49	Waste 56	Cyber & physical security -16	
Environmental	7	Assets & operations -81	Skilled workforce availability 30	Water 72		
Innovation	-30	Climate change -49	Customer relations -25	Job satisfaction 2	Climate change -49	
Relationships	7	Business model -64	Community vitality -36	Water 72	Workforce diversity 90	Customer relations -25
Reliability	-10	Community vitality -36	Job satisfaction 2	Job satisfaction 2	Climate change -49	Skilled workforce availability 30

Charles Vinsonhaler: The output is articulated using EPRI's twenty priority sustainability issues. Those were issues that we did extensive research on in 2017. We engaged with power companies and external stakeholders. We fielded surveys from over three hundred representatives from the power company, and also performed interviews to identify the most important issues for sustainability performance in the power industry.

The tool produces value based on those issues. The tool will identify an opportunity around a certain issue, so the project is going to produce a lot of value in relation to air emissions, for example.

In addition, the tool will identify a risk. It could say this project has a high risk to your water issue. So, you're creating some risks through this project. We call it a heat map. The tool produces a heat map based on your sustainability perspective as well as the estimated impacts of the project. Companies are then able to use that heat map to develop a strategy for the project.

PUF: You could show the heat map to your CEO or board of directors or Commissioners or Governor's office or other stakeholders and say, well here's how this would play out.

Charles Vinsonhaler: Yes. We currently are cautious in the way we share results with external stakeholders because we are in version one of the tool. But you captured the vision for the project, which is, we know regulators want a better articulation of the sustainability value associated with projects. We know investors are asking companies, what are you doing to ensure your projects are sustainable?

We see this suite of research and this tool eventually being something that utilities can point to and say, this is what we're doing. This is how we're capturing sustainability value. This is how we're informing our projects and the decisions we're making.

PUF: How did this get started and where does it go from here?

Charles Vinsonhaler: Solve stands for sustainability optimization leveraging value estimation. We're trying to optimize the sustainability of each project by estimating its impact on sustainability values, and those values are specific to the company.

When I mentioned EPRI's twenty priority sustainability issues, the tool allows you to adjust those issues for your company. If you feel like one of our issues should be adjusted slightly or maybe we forgot an issue, there is an opportunity to add an issue to make sure it's reflective of your company's priorities.

This is version one of the tool. That's why we have case studies with twelve companies ongoing because we recognize the value in applying the tool, seeing how members can use the tool, and learning from their experience. We can sit in the lab and make tweaks and edits, but unless it's informed by actual experiences, it's not going to be valuable for the industry.

We have a plan to release version two in 2020. Then we want to conduct case studies, test that with our members, and continue to drive enhancements. We've already seen value from

Value is specific to a utility. A company thinks about sustainability value from an internal perspective.

the tool in two ways.

First, I mentioned that the tool requires a company to prioritize issues specific to its sustainability context. We've been doing workshops with companies. We'll go to a company, get a group together, and do a workshop where we go through each issue and ask them to prioritize the issue.

These workshops have produced two results. We did a workshop at an executive retreat, and the executives had a conversation about their issues. But they hadn't thought about, what is our strategy? How are we going to invest in these issues moving forward?

We also did a workshop at a different company with managers and directors. Through the workshop they realized, hey, we both work on this same issue. I didn't know you were doing that.

Another way that we're seeing value out of the tool is we had a company that ran through the entire analysis and said, we made calculations based on the questions that the tool was forcing us to ask. We have some real numbers and data that we didn't have before. So, this tool is capturing outcomes that our current project analyses don't capture. We see the value in the tool as a framework for how we're analyzing projects moving forward.

PUF: How did you see your role?

Charles Vinsonhaler: I was there on the day-to-day. We had a

contractor help us with some of that literature because thumbing through twenty methodologies is a lot of work.

I was managing that literature review and the initial research. I came to EPRI a year ago, and this was the first project I started working on. We started with the development of the concept, and I helped develop the framework and showed that visual framework to our members, getting their feedback, and tweaking that.

Then we moved on to the tool, and that was where I used my Excel experience and did some functions and formatting on the Excel side and built the tool up from ground up. I'm familiar with the tool, and that has been helpful as we adjust and look at version two. It's been a streamlined process because we can adjust the tool in-house.

As we've been testing the tool, I've been the main point of contact on these case studies. When we did the two workshops, I was the main support. Morgan Scott was the workshop facilitator.

What the tool ultimately produces is a quantitative number, but it's informed by the qualitative perspective of that company.

Moving forward, as we have kickoff calls and talk about the case studies and where they're going, I'm maintaining that information. At the end of this year, I'll be publishing technical updates on the tool, what we've learned, and where we see the tool moving. I'll be writing and publishing that. ❍

Kim Wagie, Director of Digital Transformation, Arizona Public Service

PUF: Is your role something new?

Kim Wagie: It is a new position announced two and a half weeks ago. I've been working for Arizona Public Service for six and a half years. I started in IT with application support for the back-office applications. I also had responsibility for integration and business intelligence. I came from the insurance industry and was new to the utility industry.

I quickly realized in order to support my business partners, I needed to learn how we generate power and move energy across the grid. So I took a rotational role in the operations side of the house, specifically Fossil Generation. I learned a great deal regarding our fleet, generation equipment, and work management.

Coming out of that rotation, the COO came to me and asked, now what would you like to do? We talked and he said, I'd like you to fix our data. I asked, what does that even mean? He said, I want us to start making decisions based on facts and data rather than, I think and, I feel. And we can't do that today for various reasons. I know you'll figure it out and let me know what you need.

I took the next nine months to establish our data management, and data governance strategy and approach. I also had responsibility for data analytics as well, because while we had kicked off our advanced analytics practice and were starting to turn out some analytical models, we were finding out we had bad data and it was impacting model performance.

So, advanced analytics came in under my fold and we started to build out an organization around data management and data analytics. It was January of 2018 when they expanded my role to also include visualization, and RPA/automation, as well as the continuous improvement group and our corrective action program.

I had doubled the size of the organization and was figuring out how to leverage those unique skillsets to come up with holistic solutions for our business partners, rather than just targeting either data or analytics. We started to expand our solutions set as well.

It is about challenging the organization in areas where we haven't had this discussion before because now that the technology is so mainstream, it provides opportunities to reevaluate how we do things.

Now fast forward to September 9, and the company made an announcement launching a digital transformation hub. It was combining what I had under data management and governance, including advanced analytics, visualization, automation, and now added mobility, business intelligence, data integration, and the build out of our data lake.

PUF: A lot of it is operations and power generation, but it's everywhere?

Kim Wagie: Yes. It's everywhere. I own all internal digital solutions for the company.

PUF: What do you do if someone asks, how can we make an improvement? What are the common approaches?

Kim Wagie: We come at it a couple different ways. We ask our customers, where are their pain points? Where could our solutions provide value? Where do they want to take their

(Cont. on page 68)

Two Centers of Innovation Work More Closely

Conversation with EPRI's CEO Mike Howard
and GTI's CEO David Carroll

PUF's Steve Mitnick: Both of you run engines of innovation in the global energy sector. EPRI and GTI announced recently a memorandum of understanding to collaborate more closely on key power industry issues. What drove you to collaborate more closely?

Mike Howard: It's the recognition that working together EPRI and GTI can accelerate the deployment of technologies in low-carbon fuel production, delivery, and to ensure that these technologies are available at scale for deeper economy-wide decarbonization, especially beyond 2030.

Because our organizations play key roles in addressing the challenges in the energy sector, we can best achieve this goal by leveraging our respective areas of expertise. It goes back probably three years ago when we started thinking about the whole idea of a more integrated energy network or IEN. Foundational to the IEN is a recognition that the industry is in a transformation driven by technology and changing customer needs and expectations.

Embedded in that is a desire for cleaner energy and an acknowledgment that we are digitizing the electric system. It's becoming clearer that more outside-the-box thinking is needed when we consider how we can use all forms of energy more efficiently and more effectively. So that's number one.

Second is the reality that you can't separate gas from electricity, or electricity from gas because they are so tightly connected. We must look at gas, as well as other systems, such as water, communications, transportation, and energy, as being integral to the energy system.

Rather than looking at these as separate industries, an integrated approach will enable more efficiency, cleaner energy, control, reliability, resilience, and security in the electric power system. By engaging in discussions with more non-linear thinking we can come up with some better technical options.

David Carroll: I agree with Mike. Both organizations are working hard to develop the technologies and the pathways for safe, reliable, affordable energy, but the difference here is we are also working collectively to reduce the impact on the environment with low-carbon fuels and power. Energy companies are looking to develop sustainable pathways and clean energy options for their customers.

Also, the reality is that GTI and EPRI have been working together a long time. For the electricity generation part of this mix, the group of companies that are EPRI members are the largest collective customer for the natural gas industry.

We already have had an important connection, but when you start looking at these extended areas of convergence – things like customer choice where the end-user is making decisions about energy and fuel usage, gas for power generation, water requirements for gas and power production, energy needs to move and treat water, and so on – there's so much overlap and it is all overlaid by this evolution of data analytics and advanced technologies that are enabling the more efficient and more real-time coupling of these two types of energy.

Mike Howard: David makes a good point that I want to emphasize. We didn't just wake up the other day deciding to cooperate and collaborate. Technical staff on both sides have worked together on various projects for years.

The reality is that GTI and EPRI have been working together a long time. For the electricity generation part of this mix, the group of companies that are EPRI members are the largest collective customer for the natural gas industry.

– David Carroll

This MOU bolsters efforts by both organizations along with worldwide research on low-carbon resources. It facilitates our engagement globally, including labs and universities. We see it leading to test facilities, protocols, and demonstration projects. A key focus will be to advance analytics and technologies for hydrogen and related low-carbon resources, such as biofuel, synthetic methane, liquid ammonia production, delivery and use in the power sector and in transportation, industry, and buildings.

PUF: Give me an idea about how you work together.

David Carroll: Our relationship goes back a long way. Both organizations do program management and then perform research and technology development.

A real point of convergence between our two organizations is our increasingly overlapping customer base where you have, in the market, any number of examples – but take Southern Company, which is a very large electric distributor and natural gas distributor.

With a centralized technology function like Southern Company has, both GTI and EPRI – by our nature of strong customer relationships focused on market demands – end up crossing paths a lot. Over the years we've cooperated on individual technology projects. We've been joint owners of a

This MOU bolsters efforts by both organizations along with worldwide research on low-carbon resources. It facilitates our engagement globally, including labs and universities.

– Mike Howard

technology startup in the fuel cell field in addition to cooperating on research projects and exchanging information in a variety of different forums.

PUF: What's the business model of innovation at EPRI and GTI?

Mike Howard: At EPRI, several things serve as our foundation – that start with our global collaborative model. We can forge a common understanding of the challenges and opportunities that face global energy producers and users. Our technology scouting and assessments are stronger and travel farther in the energy sector because of our close engagement with members and stakeholders.

That same collaboration enables us to leverage the money invested in research, demonstration projects, and other actions at more than ten to one. So, a dollar invested by one company can get more than ten dollars of R&D leverage – and the strategic and operating insights that go with it.

And the need has become more urgent. We did a study to look at how innovation has changed over time. I asked, how do you gauge the pace of innovation? We looked at both U.S. and international patents going back to the 1900s. Looked at peer-reviewed journals and so on. Looked at how long it took to get a product from conception to market maturity.

The conclusion is what I call twenty-five - eight. Consider the innovations over the past twenty-five years, including cell phones, I-pads, and all the innovative things we use every day. Over the next twenty-five years innovation is going to accelerate. It's going to happen not over twenty-five years, but rather over eight years. That's what I call innovation acceleration.

David Carroll: Speaking for GTI, we are absolutely driven by a focus on our customers in our sector. At its core, the focus of R&D is driven by the market, and in fulfilling our customers' requirements. We don't wake up every morning saying, we do this kind of research or we make this kind of product. Who do we sell it to today?

No. We wake up every morning and say, here's our set of customers, be it Southern Company, or Sempra, or Shell. What can we do to help them be more successful? That intense focus creates collaboration opportunities and shared problem solving.

Again, both utility sectors, by definition, cooperate on issues critical to the energy industry, like responding to emergencies and looking at broad safety issues and so forth, so the essence of collaboration is something that's built into the DNA of both the gas and electric industries.

Back to this intense customer focus, every energy company today is thinking about the role it's going to play in this future

energy mix, which still requires safety, reliability, and affordability, but with an added dimension of reducing the impact on environment, emissions, and more. We're all in this together, and both organizations work very closely with our clients and partners to make that happen.

In our collaborative research programs, GTI applies the concept of open innovation and drives to higher value and better results by including many individuals from diverse background across many organizations. This includes both customers as well as partners like academic and other research institutions.

Mike Howard: Recently, we hosted our R&D sectors' advisory meetings, where we're tracking our progress in current research, and we're also looking ahead. Like GTI's approach, these meetings offer members globally the forum, where companies have the expectation of figuring out how we can collectively solve technical issues.

Collectively, our organizations are doing this for both electricity and natural gas. It's that ability to come together to focus on questions to be resolved or solved that makes both of us instrumental in developing innovative solutions to today's, and more important, tomorrow's challenges.

David Carroll: And from a global energy perspective, we have moved beyond the energy challenge of scarcity and now face the challenge to continue to grow our economy and standard of living using affordable, low-carbon energy systems.

At GTI, we see this more as an opportunity than as a challenge, and we see our ability to innovate and to partner with other innovators as core to our potential to help our customers successfully navigate this next transition – both here in the U.S. and around the world.

By integrating strategic insights, room to create and take risks, and visibility into our long-term business planning across the organization at all levels, we are trying to unleash the full potential of our team. We are also expanding our innovation focus to an enterprise-wide effort to develop disruptive advances in services, products, processes, or technology.

PUF: Tell us some of the exciting things that you all are working on in each of your shops separately, possibly even together, that the industry should hear about.

GTI has a lot of work underway on methane, which is the principle component of natural gas. The industry is focused – from upstream all the way through end use – on addressing methane emissions.

– David Carroll

Mike Howard: There is no single path for addressing the challenges faced by the energy sector and its diverse customers and stakeholders. Deep decarbonization presents some of our most interesting challenges and opportunities.

It's going to take GTI and EPRI working together to come up with a variety of technical solutions to figure out how to apply technologies, such as the use of hydrogen and carbon capture utilization and storage, that will enable this. GTI is doing impressive work in these areas, and we could find synergies there with EPRI's R&D portfolio.

The MOU focuses us on expanding the research that is underway. It includes advancing the analytics and technologies

GTI

GTI is the leading research, development and training organization addressing energy and environmental challenges to enable a safe, efficient, and responsible energy future. For more than seventy-five years, we have been developing innovative technology-based solutions for industry, government, and consumers.

As an independent not-for-profit organization, we provide services that benefit the natural gas industry and the public. We focus on assisting our customers in achieving their business strategies and providing the tools and technology pathways for governments to achieve their policy objectives.

Through our Public Interest Advisory Committee, we have valued relationships with public utility commissioners, consumer advocates, and other experts that provide insight and guidance on public interest issues and long-term trends that may impact the industry. Public utility commissioners have approved natural gas voluntary R&D recovery funding in thirty-one states, and there is a pending R&D surcharge case in one additional state to support projects that result in ratepayer cost savings.

GTI also works with regulators to ensure compliance with rules affecting pipeline and distribution systems, to identify best practices for implementation, and to establish guidelines for operators in obtaining regulatory compliance.

GTI solves important energy challenges, turning raw technology into practical solutions. These products and processes are being put to use every day, creating value for companies and consumers. To date, GTI programs have resulted in more than five hundred products, seven hundred and fifty licenses and one thousand three hundred associated patents. We have trained more than seventy-thousand industry professionals.

Our research initiatives address issues impacting the natural gas and energy markets across the industry's value chain – supply, delivery, and end use. We offer an integrated systems perspective to: Expand the supply of natural gas and renewable energy; Transform natural resources into clean fuels, power, and chemicals; Ensure a safe and reliable energy delivery infrastructure; Promote the efficient use of energy resources; and Reduce carbon emissions to the environment. ❍

for hydrogen and related low carbon resources such as biofuel, synthetic methane, liquid ammonia production, delivery and use in the power sector and in transportation, industry, and buildings. It also encompasses advanced nuclear, renewables, and carbon capture utilization and storage, which can be significant for enabling generation for producing hydrogen and other low-carbon fuels.

David Carroll: We're driven to serve our customers. We try to develop the technical pathways that give companies options to meet their goals, pathways to allow policymakers to achieve their objectives, and ultimately provide consumers with clean and reliable energy.

At GTI, we work across the value chain. When I say value chain, I mean upstream with the production of gas from shale to interstate pipeline transmission to distribution in cities and then finally to end use.

Let's focus first on natural gas. I'll give you just a couple of examples. We're leading some major industry consortia with support from the Department of Energy to enhance the science and efficiency of hydraulic fracturing for natural gas function.

Why that's important is, if you can get, let's say, double the gas from a given well at a lower cost, you can produce the same amount of gas with half the wells, with half the cost, and half the environmental impact. Hydraulic fracturing for shale production is still relatively new in the last decade or so on a large-scale basis, so there's still an opportunity to put a lot more science into the art of hydraulic fracturing. That's one example.

GTI and EPRI are exploring possible options for working together to introduce hydrogen as a low-carbon energy source into the global energy mix.

– David Carroll

Mike Howard: This is a good example of how technology can enable more efficient gas operations while at the same time reduce methane emissions. Today most hydrogen is produced from natural gas by a carbon-intensive process called steam methane reformation.

There are two main methods for low-carbon hydrogen production: pairing natural gas-based production with carbon capture utilization and storage, and electrolysis, the disassociation of water into hydrogen and oxygen by application of electric current from low-carbon sources.

The question is how to make those processes economic on a large-scale basis. Nuclear power plants have historically operated as baseload units. With increasing grid variability, some nuclear operators are faced with flexible plant operations. They are interested in studying the feasibility of using electricity generated during periods of low demand to produce hydrogen.

EPRI is pursuing several projects related to hydrogen storage and distributed generation, with researchers assessing the prospects

EPRI

The Electric Power Research Institute (EPRI) conducts research, development, and demonstration projects for the benefit of the public in the United States and internationally. As an independent, nonprofit organization for public interest energy and environmental research, we focus on electricity generation, delivery, and use in collaboration with the electricity sector, its stakeholders and others to enhance the quality of life by making electric power safe, reliable, affordable, and environmentally responsible.

EPRI has collaborated with the electricity sector and its stakeholders since 1972 and our membership has grown to represent approximately ninety percent of the electric utility revenue generated in the United States and extends to participation in more than thirty-five countries. The worldwide membership that supports our work comprises more than one thousand organizations. While most members are electric utilities, others are businesses, government agencies, regulators and public or private entities engaged in some aspect of the generation, delivery, or use of electricity.

Through their advisory roles in EPRI, its research sectors and programs, EPRI members help inform the development of EPRI's annual research portfolio, identify critical and emerging electricity industry issues, and support the application and technology transfer of EPRI's research and development.

Major areas include: Research supporting the safe, reliable, and environmentally responsible use of nuclear power and developing cost-effective technologies, technical guidance, and knowledge transfer tools for existing nuclear assets and new nuclear technology; Research and development providing information, processes and technologies to improve the flexibility, reliability, performance, and efficiency of fossil-fueled and renewable energy generating fleets; Transmission, distribution, and end use R&D to guide utilities and stakeholders toward a safe, secure, resilient, affordable, reliable and environmentally responsible, integrated grid; and Global thought leadership to shape a sustainable energy future through research that provides tools, technology, analysis, and guidance for environmentally sound planning and safe operation of existing generation, transmission, and distribution utility assets. ❍

of polymer electrolyte membrane fuel cells and fuel cell electric vehicles. EPRI is exploring how hydrogen production and co-production could increase the operational flexibility of new and existing power plants.

David Carroll: GTI has a lot of work underway on methane, which is the principle component of natural gas. The industry is focused – from upstream all the way through end use – on addressing methane emissions. There are a host of technologies to measure, monitor, and then also mitigate methane emissions – ranging from green completion of wells, to the capture of methane releases at well sites, to leak detection tools and monitoring systems, to the reduction of venting that takes place at metering stations, to making combustion equipment more efficient.

Getting to where EPRI and GTI are exploring close collaboration, let's talk about hydrogen. GTI is taking natural gas a step further and has a number of projects focused on generating clean hydrogen using hydrocarbon fuels that incorporate carbon capture and/or carbon sequestration in a cost-effective manner.

GTI and EPRI are exploring possible options for working together to introduce hydrogen as a low-carbon energy source into the global energy mix – from a power production standpoint, to its potential for energy storage, as well as an end use combustion source of heat and, frankly, as a feedstock in the chemical industry.

A partnership between us would form a powerhouse of expertise to address a molecule and an energy source that could be pervasive across our economy, and useful in a number of sectors of both energy and the broader economy. Who better to work together than EPRI and GTI with their long histories of serving this business?

EPRI is exploring how hydrogen production and co-production could increase the operational flexibility of new and existing power plants.

– Mike Howard

We've worked together in the past. Let's call it opportunistic. With this MOU, it implies that our working together is intentional to meet our customers' demands. Customers are facing challenges of safety, reliability, affordability, and now are also looking for clean and sustainable energy solutions.

There's a compelling need for the relative skills of our organizations to work together. An MOU like this implies focus. It implies commitment. It may even imply investments in the future but, at the least, a shared set of goals and vision.

There's more work to be done on defining what it will exactly look like, as customers will shape the market opportunity. But this collaboration clearly expresses an intent to invest in a considerable effort getting aligned and focused on addressing the challenges and issues of the broad global energy industry.

Mike Howard: The hydrogen market is a good example because there are various ways to get hydrogen and take advantage of

(Cont. on page 65)

EPRI Considering Hydrogen More Broadly, More Strategically

The First Element Could Be Even More Important

For years EPRI has considered and discussed the potential for hydrogen and the electricity sector to combine in a more integrated energy system. As EPRI continues to broaden its portfolio, some recent and current examples provide a good understanding of the portfolio's scope and direction with respect to energy production, delivery, and use.

Among the options for hydrogen are its potential to serve as: A source of large-scale electricity demand (if produced by electrolysis); Value-added co-product to increase the flexibility of power plants; An energy carrier for decarbonizing hard-to-electrify sectors; An emerging fuel for both distributed (fuel cell) and utility-scale (gas turbine) power generation.

Power-to-Gas Frameworks

In 2014, EPRI published a technology brief looking at the Power-to-Gas or P2G frameworks in which renewable electricity is converted to gaseous fuels such as hydrogen via electrolysis. The brief outlined the potential value of harnessing variable-output renewable energy for producing hydrogen for direct use, or for injection into natural gas storage and delivery networks for use in electricity generation, heating, transportation, and other applications.

In its 2017 review of the Uniper Energy Storage GmbH Power-To-Gas (P2G) Demonstration Projects in Germany, EPRI reported on projects that sought to: Demonstrate the coupling of intermittent surplus renewable energy to the storage capacity of the natural gas grid using conventional alkaline electrolysis cell (AEC) based systems to generate hydrogen, which was then fed into the high-pressure transmission gas grid; and Demonstrate the potential of proton exchange membrane electrolysis cell (PEMEC) technology to generate hydrogen for P2G systems.

Based on these projects, PEMEC technology emerged as the then leader for prospective P2G facilities based on its footprint, efficiency, dynamics, and opportunity for cost reduction. The report emphasized that under the given market conditions, the simple arbitrage model implemented by these projects (purchasing electricity under normal commercial terms) was not a viable economic model. It pointed to the need for other market mechanisms for viable P2G projects to address opportunities for integrating the electricity, heat, transportation, and chemical sectors.

Further EPRI Research

Under a DOE H2@Scale award, EPRI is working with NREL to apply production cost modeling for integrated assessment of the impact of hydrogen technology deployment to overall electricity system operations through functions such as demand response, frequency support, and long-duration energy storage.

Earlier this year EPRI reported on an extensive review of prospects for the large-scale production of hydrogen by water electrolysis. It examined technologies, costs, and economic assessments and reported on electrolyzers' prospective of key performance indicators with respect to capital cost, efficiency, and operating lifetime.

EPRI's generation and nuclear sectors are exploring how integrated hydrogen production and co-production could increase existing and new power plants' operating flexibility.

The study found that electrolyzer manufacturers worldwide are actively developing large-scale alkaline and PEM technologies, some of which are close to meeting the efficiency and lifetime requirements for large-scale hydrogen production. Based on the likely performance of emerging PEM and alkaline electrolyzers, the analysis indicates that electricity costs of 2¢/kWh or less will be necessary to produce hydrogen from electrolysis at a cost $2/kg or less.

EPRI's generation and nuclear sectors are exploring how integrated hydrogen production and co-production could increase existing and new power plants' operating flexibility. EPRI's Flexible Plant Operations Program – with U.S. Department of Energy's Light Water Reactor Sustainability Program – is examining the feasibility and potential demonstration of minimizing plant "cycling" by co-producing hydrogen during periods of low demand. EPRI's Advanced Nuclear Technology Program is scoping potential deployment models for hydrogen production from advanced, high-temperature reactors.

EPRI's Generation Sector R&D staff are taking an informed look at what R&D is needed with respect to hydrogen as fuel for power generation. Gas turbines and engines may emerge among the end-use equipment most sensitive to new fuel mixes.

EPRI technology scouting reports have reviewed potential impacts of hydrogen fuel on materials and combustion systems. EPRI projects the need for in-depth research, including case-by-case consideration.

EPRI transportation research is expanding its scope to consider fuel cells. After more than twenty years of significant efforts to develop automotive proton exchange membrane fuel cell (PEMFC) technology, producers of fuel cell electric vehicles (FCEVs) are

(Cont. on page 65)

GTI – Enabling Broader Use of Hydrogen Across the Energy Infrastructure

A Low-Carbon Resource

GTI successfully designed, built, and installed a waste gas clean-up system and hydrogen generation infrastructure at Joint Base Lewis-McChord's water treatment plant in Washington state to operate military base vehicles using hydrogen-powered fuel cells.

GTI has a significant track record and a long-standing commitment to hydrogen research and technology development. As an established leader in hydrogen and fuel cell technology, the organization has initiatives across the energy value chain, focused on hydrogen generation, transport, storage, and use. The focus on hydrogen as a low-carbon resource is increasing with the global movement toward economy-wide deep decarbonization.

Hydrogen has been used in refinery operations and as an industrial gas for several decades. It has been viewed as a potential vehicle transportation fuel and as a fuel for on-site power generation since the 1990s or even earlier.

Now however, hydrogen has emerged as a potential solution for large-scale energy storage and delivery, including power-to-gas and renewable energy transport in existing pipelines. Hydrogen can be the link that enables the nation's existing, widespread, and robust energy infrastructure to facilitate the introduction of new and emerging renewable energy technologies.

GTI is working with its industry and government partners to establish that link by developing technologies and processes that support the broader use of hydrogen. The organization is involved in research, product development, and demonstration projects that highlight the latest in emerging hydrogen technologies.

Hydrogen Generation

Hydrogen can be generated from several different feedstocks through a variety of processes. Selecting the best hydrogen generation technology often depends on the application. For example, GTI's compact hydrogen generator is an industrial-scale generation process that offers an inherent carbon-capture capability.

When combined with new turbine technologies, it yields near-zero carbon emissions power generation. A significant cost of hydrogen is transporting hydrogen to its end-use. GTI has developed technologies to make hydrogen on-site from a variety of feedstocks.

GTI's micro-scale steam methane reforming technology utilizes renewable feedstocks such as landfill gas or digester gas to generate hydrogen. In addition, GTI has a liquid phase reformer that delivers pure hydrogen at pressure from renewable liquid feedstocks. These technologies have applications for hydrogen vehicle fueling stations, for remote and back-up power generation, and other distributed applications.

Hydrogen Storage and Transport

Hydrogen is an emerging option for energy storage in existing gas pipeline networks. Determining appropriate hydrogen blends, operating conditions, and end use equipment compatibility for large-scale infrastructure deployment involving hydrogen are some of the key issues that GTI can address by leveraging its expertise and research strengths in pipeline operations.

For example, GTI and the University of Texas are partnering with the U.S. Department of Energy and several commercial companies to design, build, and operate the first dedicated hydrogen infrastructure network under the Department of Energy's H2@Scale program. The three-year project integrates existing and new technologies to demonstrate the safety and reliability of natural gas/hydrogen networks.

Hydrogen can be the link that enables the nation's energy infrastructure to facilitate the introduction of new and emerging renewable energy technologies.

Mobility

GTI has led several demonstration projects to validate the technical and environmental case for hydrogen-fueled, fuel cell vehicles. Delivering infrastructure, vehicle, engine, fuel dispensing, and system solutions for clean transportation fuel cell vehicles has helped to further the use of hydrogen as a transportation fuel.

Heavy-duty trucks, buses, port vehicles, passenger vehicles, forklifts, and even aerial drones are part of GTI's extensive fuel cell mobility program. Frontier Energy, a subsidiary of GTI International, has managed the California Fuel Cell Partnership, an industry-leading consortium of car makers, fuel suppliers, government agencies, and fleet operators since its inception.

Innovative pre-cooling technologies for hydrogen dispensing, materials-based storage designs to increase capacities at lower pressures, a process for accurate filling of high-pressure hydrogen cylinders used for vehicle fuel storage, and a hydrogen compression technology using a free piston linear drive mechanism that dramatically reduces costs are among the successful innovations from the GTI team.

Codes and Standards/Training

GTI staff has participated in codes and standards development for hydrogen and fuel cell vehicles for over twenty years. The research team has played a key role in NFPA, ICC, SAE, CSA, and other pertinent working groups involved in standardization

GTI designed and installed hydrogen fueling facilities in the greater Columbia, South Carolina area.

of fueling protocols, building codes for hydrogen facilities, and ground storage requirements.

Under a recent U.S. Department of Energy grant, GTI created and implemented training workshops for the design and operation of hydrogen vehicle maintenance facilities. GTI's Frontier Energy subsidiary provides additional education and outreach programs on fuel cell vehicle operations via the California Fuel Cell Partnership.

Renewable Hydrogen

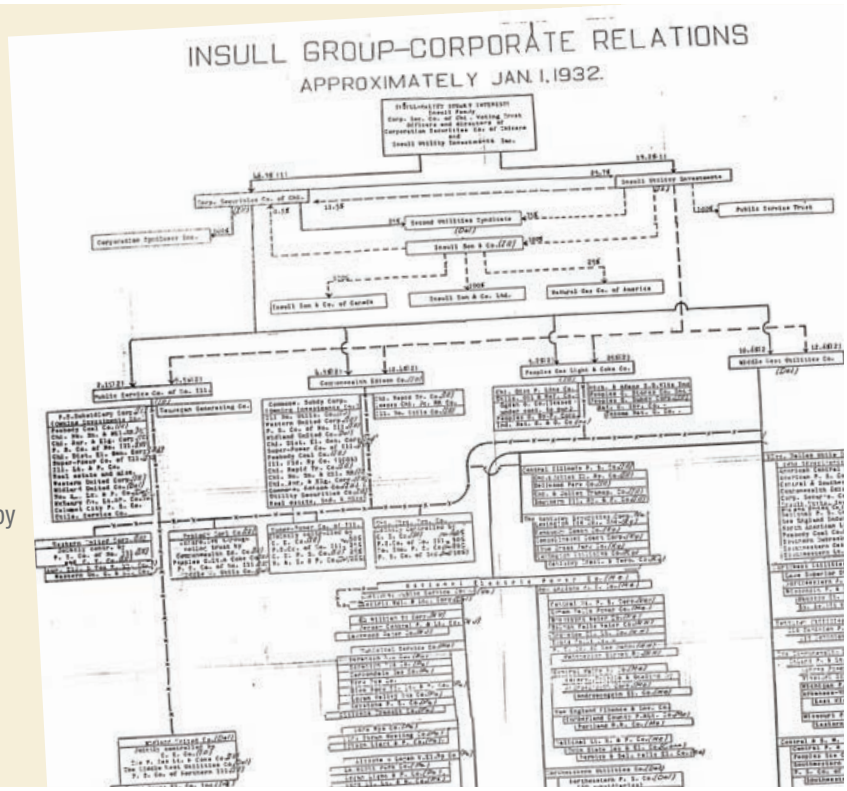
GTI has a long history of building and operating on-site hydrogen generation and dispensing stations that use renewable feedstocks such as landfill gas and digester gas. GTI has been a leader in gasification technology since it's work with the National Energy Technology Lab began in the early 1970s. One of the major components of gasification "syngas" is hydrogen.

GTI's SunGas Renewables subsidiary leverages its technical strengths in gasification and hydrogen to offer a woody biomass to

GTI has piloted a hydrogen production process that offers a cost-effective approach for pre-combustion carbon capture.

pure hydrogen solution at large scale, up to twelve billion SCF per year. This approach uses GTI's commercial gasification platform and conventional back end clean up technology to reliably deliver green hydrogen at scale. PUF

In the late nineteen-twenties and early nineteen-thirties, Samuel Insull controlled over half the electric and gas utilities in the United States through a vast empire of holding companies. This analysis of his empire by the Federal Trade Commission in 1932 is a prized historical document from the archives of Public Utilities Fortnightly. By then, there was widespread criticism by politicians and the media of this financial structure for one of the nation's largest industries and blame for precipitating and prolonging the great depression. Including by the likely nominee of the Democratic Party for the presidential election that fall, New York Governor Franklin Roosevelt. Most investor-owned utilities in the present day have their origin in an Insull utility listed in this FTC analysis.



EPRI Hydrogen

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bringing to market limited numbers of these vehicles. EPRI is interested in understanding the prospects for large numbers of these vehicles to impact electric utility energy supply planning – looking at the next five to ten years and beyond.

EPRI's recently published update concludes that the technology offers competitive performance, but the technology still does not meet the combination of low cost and long life required for broad commercial viability. Uncertainties remain concerning the ultimate potential of PEMFC technology, widespread availability of cost-competitive hydrogen fuel, market segment fit, and overall market potential of FCEVs. Mass production is unlikely before the mid-2020s at the earliest – and then only if all technology life and cost issues are positively resolved and necessary production commitments are made within the next three to five years.

EPRI recently released a brief that examined safety considerations of blending hydrogen in natural gas delivery systems, which presents a range of potential energy benefits. Recent feasibility studies have found that blends of approximately five to twenty percent hydrogen can be accommodated by most networks with little increased risk. EPRI is pointing to opportunities for case-by-base safety/risk assessments to consider the varying characteristics of local/regional gas infrastructure and end-use systems. PUF

Two Centers of Innovation

(Cont. from p. 59)

its environmental benefits. Whether you burn it or oxidize it through a fuel cell the only emission is water.

You could use electrolysis to get the hydrogen from the oxygen, and then that gas can potentially be delivered through the gas pipeline system. You could use renewable energy, or you could use nuclear power as the raw material.

You end up with a zero-carbon output that could then be used in a variety of industries, including steel and transportation or as an energy storage mechanism. A driving force in the renewed interest in hydrogen is its scalability for bulk storage.

Current battery technologies don't lend themselves to bulk storage as do pumped hydroelectric storage or compressed air energy storage, but both of these are capital-intensive. On a smaller scale, hydrogen storage could smooth the variability of wind and solar generation, using the excess electricity to generate hydrogen. The same way we refine millions of gallons of gasoline a day, we could potentially produce millions of kilograms of hydrogen from renewable generation.

PUF: If I look five years out, what do you think this increased cooperation might look like?

David Carroll: It will be increased cooperation, but we're not at a point to say exactly what it might look like. I have some ideas, but we have to take some steps to make sure that what we do together is better than doing it separately, that the result will add up to something much more than the sum of the parts.

What I do know is this – whatever we do together will offer enhanced value to the key energy players that we both work with. Both GTI and EPRI have extensive experience in the convergence of different energy forms coming together on a smaller-scale community-based system and integrating renewables, advanced technology, existing energy sources, biomass, and hydrogen.

> **The objective is to create a future with more energy and much less carbon.**
>
> ***– Mike Howard***

What the energy companies are looking for is our help to define and articulate that pathway so that they can meet the reliability, cost, and safety needs that their customers demand at the same time they are reducing the impact on the environment.

If we're successful, we'll be doing a lot of joint projects. There might even be some type of additional framework that focuses on a particular mission. Our success in creating value for the market will help to define that. We're going to start small, but we're definitely thinking big here.

Mike Howard: A fundamental key to our collaborative is to create a risk-informed understanding of options and technologies for economy-wide deep decarbonization through engineering and technology demonstration.

The objective is to create a future with more energy and much less carbon. PUF

The question is sometimes asked. Why did Samuel Insull, as president of the National Electric Light Association (the predecessor to the Edison Electric Institute), propose utility regulation to a hostile audience at NELA's annual convention on June 7, 1898? Certainly he saw regulation as required to provide utilities the creditworthiness to raise massive amounts of capital to electrify the nation. But Insull was raised in England. He believed socializing certain commercial activities was necessary for the common good.

AVANGRID Innovation Forum, October 10

AVANGRID, with regulated utilities in Connecticut, Maine, Massachusetts, and New York, and the nation's third largest wind power producer, held its Innovation Forum in Orange, Connecticut on October 10. The forum's theme, Innovation for Sustainable Development.

Cornell University students Shikhar Prakash and Tumani Edwards walked away as winners of the six-month Better Energy Future Innovation Challenge. There were also teams from Harvard University (Milan Bhandari, Charles Hu, Keshav Rastogi), Massachusetts Institute of Technology (Janak Agrawal, Talha Faiz), University of Connecticut (Himaja Nagireddy, Feifei Yang), and Yale University (Martin Cilloniz, Marc Potin).

During the event, AVANGRID showcased its collaboration with the Tsai Center for Innovative Thinking at Yale University and signed a three-year agreement with Yale to partner on clean energy research.

Mansur Ali Mohammed, AVANGRID senior manager – IT architecture, digital and innovation, talks about a demo project to use technology to help field crews locate underground infrastructure.

AVANGRID deputy CEO Bob Kump, center, poses with a Pole Caddy safety device developed by employees Mark Waclawiak, left, and Andrew Kasnay, right.

Agustin Delgado, chief innovation and sustainability officer at Iberdrola, AVANGRID's global partner.

AVANGRID CEO Jim Torgerson signs an agreement to collaborate on research with Yale University. Yale School of Forestry and Environmental Studies Dean, Ingrid Burke, at right.

Frank Reynolds, COO, Berkshire Gas (an AVANGRID utility).

Winning innovation team five, second and third from left, Shikhar Prakash and Tumani Edwards, both from Cornell University, and AVANGRID advisors Mark Waclawiak, far left, Jim Mader, second from right, and Devang Patel, far right. Their project: Fortifying the Grid to Deliver Uninterrupted Access.

Visiting EPRI Innovators, in Charlotte

(Cont. from p. 15)

a conductor that wasn't acting quite right, we would call up the manufacturer, say, hey, we've got this issue here.

A lot of times we have the manufacturer install these lines. We do the testing. Therefore, they can't say we installed it wrong or not the way they do it.

PUF: Maybe they say, hey, we're glad you found that. We'll go back to the lab.

Sam Harrell: Some of this is prototype equipment. We're here for the good of the public to make sure that we're providing accurate results. We don't endorse any product whatsoever. We do make some stuff that we think would help the industry. But that's one of our missions. ❍

Reactor Inspection Lab

PUF: This is the wall for a pressurized water reactor?

Paul Weeks: Yes. This is an outlet nozzle. It's a very heavy piece, and we have to have specialized equipment to pick it up.

PUF: Right, because the wall is very thick. And the boiling water reactor is over here?

Paul Weeks: Yes. This is a real reactor vessel. This came from, River Bend, I believe, because they didn't finish the second unit. So, it was stopped, and EPRI has been able to work with many of the utilities where they stopped construction.

PUF: So, you got this off of eBay?

Paul Weeks: Yes. We paid a dollar for it, and cut up these pieces, and we use these for testing. Then we had flaws implanted in them.

We do procedure personnel demonstration for the reactor units. The pieces, the nozzles, and the actual shell.

PUF: How do you do that?

Paul Weeks: I don't even know. The companies that do it for us use proprietary methods.

There's a lot that goes into making a good weld bad, and making it look like a real flaw in the field.

That's important. You have to make sure it looks like a real crack. Our group is always involved in going out in the field when plants have issues and helping them evaluate things.

PUF: At Vogtle, these nozzles, they had them there, so I guess they are transported there. But as far as their insertion into the right part of it, they were really careful about it. This is critical equipment.

Paul Weeks: Absolutely. In this area, we do procedure personnel demonstration for the reactor units. The pieces, the nozzles, and the actual shell. These are upper head penetrations.

PUF: What does that mean?

Paul Weeks: That is for like in a pressurized water reactor on top of the head, there are control rod drives in the top of the head. These are the penetrations.

PUF: These are the rods into the bath, so to speak.

Paul Weeks: So, we check the welds on those. Also, we do studs and bolts. These are the reactor studs. They hold the head on, and they basically clamp the head down.

Any forty-eight or sixty-four of these go in. There's a lot. You can inspect these with ultrasonics also. PUF

Samuel Insull was twenty-one when he stepped off a boat from England on February 28, 1881 and was taken to 65 Fifth Avenue to meet and start as Thomas Edison's personal secretary, just over a year since Edison's filing for the light bulb patent.

(Cont. from p. 53)

organizations? Additionally, our IT team did an exercise where they did business capability roadmaps with every one of our business partners to say, where are you today and where do you want to be in three to five years from a capabilities perspective? How can technology help support your initiatives and growth in each business area?

We are constantly looking where there are efficiencies to be gained in the organization, where is there waste, and which activities are non-value add work that we could eliminate or automate.

We overlay that with what we've seen happening in this space and where other utilities and companies are having success. It's consolidating all of those inputs, and we start to formulate through our intake process a prioritization list where we think we will get the biggest value.

PUF: There's a connection between creativity and innovation, but you're open to different approaches?

Kim Wagie: Yes. We're trying to teach our organization how to do things differently. We have a long tenured employee staff, and often fall back on this is the way we've always done it.

There is an element of change and we come along and say, have you ever considered doing it this way? We might ask, could we automate this process or use the data to make decisions? There will always be a need for intellectual decision making, but automate where you can.

It is about challenging the organization in areas where we haven't had this discussion before because now that the technology is so mainstream, it provides opportunities to reevaluate how we do things.

PUF: What is an example of something where you felt it had the biggest impact?

Kim Wagie: An example is a proof of concept we did for our wood pole program. Almost all of our asset classes are treated on schedule-based maintenance. We are moving to a condition-based maintenance program and layering on risk.

Historically, we would hire an inspection crew and send them out randomly to inspect our wood pole fleet. They would pick a feeder, walk the line, randomly sample x number of poles, send in the sample and get the results back. That process took significant time and cost. Plus, our hit rate, meaning the number of poles inspected and the percentage of that we needed to see replaced, was less than two percent.

It wasn't an efficient process. So, we built an analytical model where it took in various attributes like the wood species, location, soil type, and the maintenance history. Based on those attributes, an analytical model can now predict which poles will need replacement and when. Now we send out our crews in targeted areas to do that evaluation and our hit rate is almost ten percent. Plus, we look at the risk of failure and impact to reliability to help determine where we should be making the asset investment.

The ultimate goal is to become a digital utility.

We're taking that same methodology and are now applying it to all our major asset classes in T&D.

PUF: Where do you see this going in the next two, three years?

Kim Wagie: We're selecting what we call journeys, whether that's customer experience, asset health, or worker in the field. We're selecting which journeys are most viable and impactful to customer experience and affordability. Those are our primary pillars.

We're picking use cases that support those journeys. Over the next two to three years we'll be doing various use cases that roll up to those particular journeys to help improve the consumer experience and/or help affordability.

The ultimate goal is to become a digital utility. It's more than getting rid of paper. It's around having accurate data in the right place at the right time and made easily accessible to our internal customers so they can do their work efficiently and effectively. PUF

In a lecture before Philadelphia's Franklin Institute on March 19, 1913, Samuel Insull described his Lake County Experiment, combining small communities' utilities to reach economies of scale enabling much more rapid electrification of rural America.

PUBLIC UTILITIES FORTNIGHTLY

Impact the Debate

Public Utilities Fortnightly (ISSN 1078-5892) is published monthly with additional issues published in February, June and November by **Lines Up, Inc.** Executive and editorial offices at 3033 Wilson Blvd., Suite 700, Arlington, VA 22201. Tel: 703-842-3758, Email: info@fortnightly.com

POSTMASTER: Send address changes to Public Utilities Fortnightly, 3033 Wilson Blvd., Suite 700, Arlington, VA 22201. Periodicals postage paid at Arlington, VA and additional mailing offices.

SUBSCRIPTIONS: $500 per year, except for employees of organizations with a hundred or more employees, whose organization must have a PUF organization-wide membership. Copies not delivered due to subscriber's failure to send change of address six weeks in advance cannot be replaced. Replacement copies must be claimed within 30 days of cover date for free replacement.

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Advertising Index

Sam Insull

On November 11, 1859, one of our industry's greatest founders, **Sam Insull**, was born in London, England. Starting out as Thomas Edison's private secretary, Insull literally created our system of regulated monopolies and cost-of-service regulation.

It was June 7, 1898. In the last six years, he had built up Chicago Edison Company as its president. Now also president of the National Electric Light Association (predecessor to today's Edison Electric Institute), at age thirty-nine, he rose that morning to deliver the welcoming address of the NELA annual convention.

In six historic sentences, Insull outlined our industry:

"While it is not supposed to be popular to speak of exclusive franchises, it should be recognized that the best service at the lowest possible price can only be obtained, certainly in connection with the industry with which we are identified, by exclusive control of a given territory being placed in the hands of one undertaking."

So, first, Insull proposed our system of regulated monopolies.

"In most European countries public-service operations enjoy exclusive franchises, under proper control, and are able to obtain capital for their undertakings at the lowest commercial rates, thus materially affecting the cost of their product...

In order to protect the public, exclusive franchises should be coupled with the conditions of public control, requiring all charges for services fixed by public bodies to be based on cost plus a reasonable profit. It will be found that this cost will be reduced in direct proportion to the protection afforded the industry."

In these three sentences, Insull proposed our system of cost-of-service regulation.

"The more certain this protection is made, the lower the rate of interest and the lower the total cost of operation will be, and, consequently, the lower the price of the service to public and private users. If the conditions of our particular branch of public service are studied in places where there is a definite control, whether by commission or otherwise, it will be found that the industry is in an extremely healthy condition, and that users and taxpayers are correspondingly well served."

> **Insull literally created the exquisite system of regulated utility monopolies and cost-of-service regulation.**

And in these last two sentences, Insull makes the case that our system of regulated monopolies and cost-of-service regulation provides the public the best value.

He established the NELA Committee on Legislative Policy to press for state utility commissions. But the committee was hamstrung. The convention generally saw Insull's proposals as too radical.

The industry, increasingly concerned about municipal takeovers of electric utilities, eventually came around. NELA established a Committee on Municipal Ownership in 1904, which became the Committee on Public Policy in 1906.

The perfect storm took place in 1907. The Committee laid out the principles of state utility commissions in a report. Then, the Panic of 1907 happened, tightening credit for everyone including municipalities.

Then, the National Civic Federation, an organization that brought together business, labor and political leaders, published detailed recommendations for state utility commissions in three volumes.

Of course, Insull was a key player in the Federation. As was John Commons of the University of Wisconsin. The distinguished economist and labor historian set down the principles for Wisconsin's regulation of utilities.

Almost exactly eight years after Insull's speech at the 1898 NELA convention, on July 9, 1907, Wisconsin became the first state to empower a commission to regulate the charges of public utilities. Massachusetts and New York quickly followed suit. PUF

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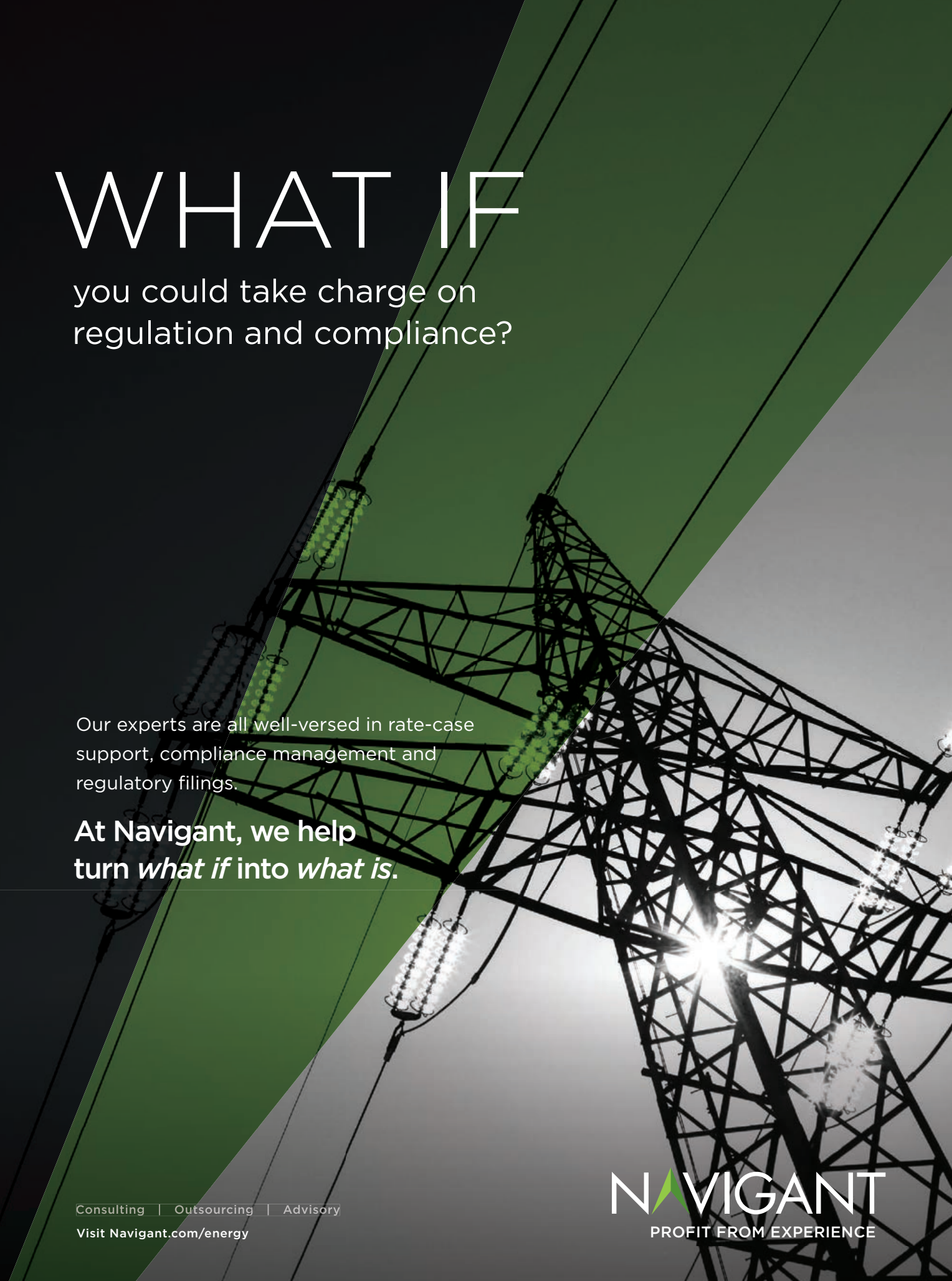
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