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*Plus: AEIC Top 10 Awards
Undergrounding Innovation*

Fortnightly Top Innovators 2021

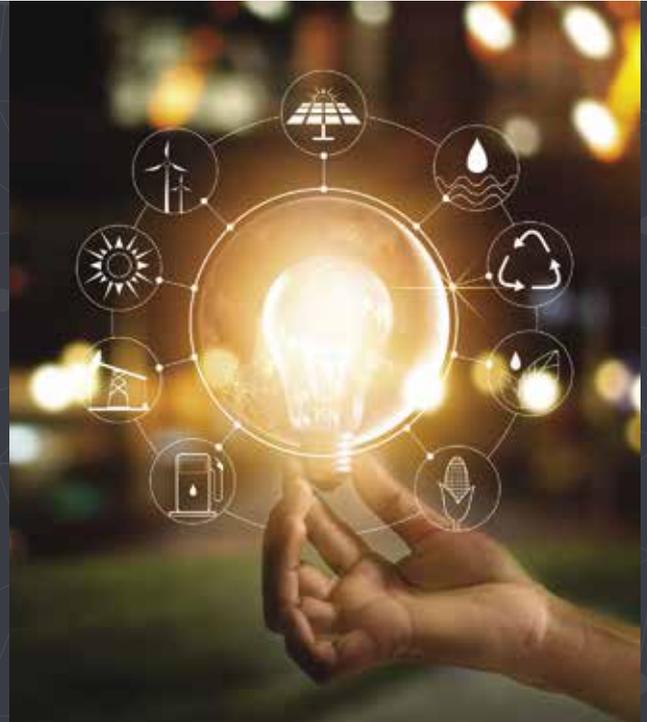




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All of this year's Inspiring Individual and Teams of Innovators, from Ameren Illinois, Ameren Missouri, Arizona Public Service, Avangrid, Burns & McDonnell, California Public Utilities Commission, CenterPoint Energy, ChargerHelp!, CPS Energy, Duke Energy, Electric Power Research Institute, Franklin Energy, Hitachi ABB Power Grids, Jones Onslow EMC, LineVision, Maryland Public Service Commission, Moody's Investors Service, Opus One, PPL, San Diego Gas & Electric, Southern California Gas, Urbint, and Xcel Energy.

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Cover photo, top row, l-r, Arizona Public Service's Miguel Bravo, Xcel Energy's Nadia El Mallakh. Second row, l-r, Arizona Public Service's Christine Helmuth, CenterPoint Energy's David Mercado, PPL's Horst Lehmann and Eric Rosenberger. Third row, l-r, CenterPoint Energy's Eric Easton, Arizona Public Service's Jim Holbrook, Southern California Gas' Eric Coene, California Public Utilities Commission's Commissioner Genevieve Shiroma. Fourth row, l-r, Southern California Gas' Ron Kent, California Public Utilities Commission's Forest Kaser and Leuwam Tesfai, Southern California Gas' Matt Gregori.

Innovation Imperative

Fortnightly Top Innovators, AEIC Top 10 Awards,
Selective Undergrounding

BY STEVE MITNICK, EXECUTIVE EDITOR

It should be obvious by now that a culture of innovation is an imperative for the utilities industry. If only because the challenges we face, from the threat of climate change to the demand for customer centricity to the complexity of today's grid to the aging of the legacy infrastructure, and so on and so on, require continuous learning, invention, and integration.

Public Utilities Fortnightly started publishing an annual special issue on innovation back in 2017. Each year's special issue has featured the Fortnightly Top Innovators, which uniquely highlights and celebrates individual innovators or small teams of innovators. In the 2021 special issue on innovation herein, the PUF team does this for the fifth year.

In the 2017 special issue, for example, we cited the Electric Power Research Institute's Maria Guimaraes for her wall climbing robot and Andrew Phillips for his line crawling robot. And the New York Power Authority's Emilie Bolduc for her "New York Energy Manager" and Ricardo DaSilva for his utility-wide digital hub.

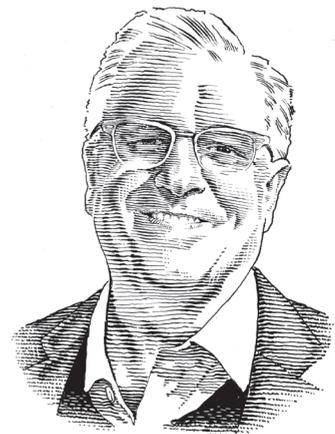
In the 2018 special issue, again for example, we cited Ameren's Cole Crews for the first private LTE network and Hawaiian Electric's Rebecca Dayhuff Matsushima for her model distributed generation contract. And Commonwealth Edison's Shay Bahramirad and Sandor Williams for

their smart grid pilot in a low-income Chicago community.

In the 2019 special issue, again for example, we cited San Diego Gas and Electric's meteorology team for their breakthroughs on wildfire prediction and mitigation. And Public Service Electric and Gas' Alexa team for their real-time customer service app.

Last year, in the 2020 special issue, again for example, we cited Burns & McDonnell's Zachary Wassenberg for virtual reality wearables. And Xcel Energy's drones team that pioneered remote and distant inspection of wind turbines.

Among this year's Fortnightly Top



Public Utilities Fortnightly started publishing an annual special issue on innovation back in 2017.

Innovators, it's tough to pick one or two particularly accomplished innovators among so many of them. With that said, there's the Arizona Public Service team for their fast-track emergency air conditioning program, the California Public Utilities Commission team for their program to accelerate microgrid adoption, and the CenterPoint Energy systems operations team that creatively coped with the Winter Storm Uri generation system outages, maintaining electric service for Houston area customers with less disruption.

Hold on. There's more in this special issue of PUF on awards that applaud industry innovators.

Thomas Edison founded the Association of Edison Illuminating Companies in 1885. Just three years >>

Steve Mitnick is President of Lines Up, Inc., Executive Editor of Public Utilities Fortnightly, and co-author of a new book, "Front Lines to Power Lines," and before that the author of "Women Leading Utilities, the Pioneers and Path to Today and Tomorrow," "Lewis Latimer, the First Hidden Figure," and "Lines Down: How We Pay, Use, Value Grid Electricity Amid the Storm." Mitnick was formerly an expert witness in proceedings before the 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.



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The simulator is said to be an immersive and memorable experience, literally vibrating your chest while you feel the air around you rapidly heating up.

had passed since he jump-started the electricity industry with the opening of the first central power plant, Pearl Street Station. Now in its hundred and thirty-sixth year, AEIC is still fostering collaboration across the industry through its prestigious committees, as Edison intended, particularly in all facets of electric operations.

To further foster collaboration and learning what's working well and what's not working as well, AEIC recognized ten industry innovations this year. They're calling them the Top 10 Awards. Commonwealth Edison earned two of the ten, and the other award-ees were Con Edison, Duke Energy, Eversource, Florida Power and Light, the New York Power Authority, PPL Electric Utilities, Tampa Electric, and the Tennessee Valley Authority.

One of my favorites is the Eversource award. To better detect and analyze momentary electrical outages that customers experience, in its "Give Me a Moment" project, Eversource automated the integration of data from multiple systems to provide a holistic view of the distribution network. They named the new tool ARCHIE, which stands for Analyzing Reliability and Circuit Heuristic Impacts at Eversource.

Another favorite among the AEIC Top 10 Awards is Commonwealth Edison's development of a four-hundred-and-eighty-volt arc flash simulator. It's meant to give utility employees a greater respect for hazards, so they're less complacent going forward when dealing with energized equipment. The simulator is said to be an immersive and memorable experience, literally vibrating your chest while you feel the air around you rapidly heating up.

Check out the details on all the Top 10 Awards within this special innovation issue of PUF. But I cannot resist telling you all about a third favorite of mine. The New York Power Authority is deploying drones to inspect its vast network of lines crisscrossing the Empire State. To pull this off comprehensively and securely, it simultaneously deployed a private LTE network of communications.

And there's more in the special issue, as there is more and more innovation in the utilities industry. There's never been so much invention as there is today in the technology and strategies of transmission. In this issue, we focus on the game-changing advancements in the selective undergrounding of transmission. **PUF**



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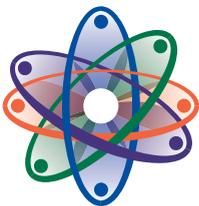
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PG&E's Landmark RFI to Underground Ten Thousand Miles of Lines

They're Innovating Undergrounding

Now a Twenty-First Century Resilience Strategy

BY PUF EXECUTIVE EDITOR STEVE MITNICK

It began snowing on Sunday night. By Tuesday, which was the thirteenth of March, back in 1888, twenty-one inches had fallen on New York City. With winds of nearly hurricane force, drifts of snow were as high as thirty feet.

Most terrifying to New Yorkers were the collapsing poles with their many cross arms from which the wires of Western Union Telegraph Co., Gold and Stock Ticker Co., and four competing electric companies – United States, Metropolitan, Brush, and East River – were hung. Gyrating wires hissed and sputtered. Fearing electrocution, people stayed indoors.

The one exception were the lines of the Edison Illuminating Co. Thomas Edison buried his company's wires underground in conduits he called "subways."

A few months afterwards, the mayor demanded that all the companies' wires, not just Edison's, be buried underground. According to the author of a book about the Great Blizzard of 1888, whose name was Mary Cable coincidentally, "the poles began to fall like forest oaks, and wires were rolled up and taken away... Crowds followed the workmen and cheered and cried 'Timber!' as the poles hit the ground."

Despite the undergrounding that was completed in New York quite resolutely, by the summer of 1889, distribution lines across the rest of the United States are generally uninsulated wires strung along wooden poles. This has been the model our industry has closely followed since its earliest days.

It was natural for the first electric companies to adopt the overhead standard in the late nineteenth century. For the telegraph companies had been stringing uninsulated wire along wooden poles since the first half of the century.

The first electric companies also copied how the gas industry worked in the Gilded Age. A gas company built a network of pipes to reach individual homes and businesses throughout

"The poles began to fall like forest oaks, and wires were rolled up and taken away... Crowds followed the workmen and cheered and cried 'Timber!' as the poles hit the ground."

gone further, in copying the gas companies. Like the Edison Illuminating Co. in New York, they could have built underground networks. But the electricians did not end up doing this, of course, except in some densely populated urban areas. Why is that?

It has been less costly to string uninsulated wires along wooden poles, to distribute electricity within communities. Doing so is also faster. Though poles and overhead wires do all too frequently fail and fall in extreme weather, they have been easier to repair because the problems Mother Nature causes are clearly visible. Wooden poles were also favored in electric distribution over stronger concrete or steel poles, because of cost and safety (wood doesn't conduct electricity and does give way a little to the occasional crashing vehicle).

Yet, as we have experienced the effects of innovation in all aspects of our industry, so too has innovation revolutionized the conversion from "overheading" to undergrounding. Converting selected overhead wires to underground cables has consequently become a compelling option for utilities across the country. Particularly those utilities that are in a seemingly endless war against the ruthless enemies of overhead distribution – high winds, heavy snow and icy rain, intrusive vegetation, wildfires.

Notice my use of the term conversion. It has always been true, and it remains true today, notwithstanding the innovations that have slashed the costs of undergrounding, that erecting an overhead distribution wire is cheaper than burying an underground cable connecting the same two points. But so what? The decision facing utilities in the twenty-first century is rarely, should we

a community, supplying the pipes with gas from a central pumping plant. An electric company similarly built a network of lines to reach individual homes and businesses throughout a community, supplying the lines with electricity from a central generating plant.

The electric companies could have

Well before he began leading Public Utilities Fortnightly, in the years 2002 through 2005, **Steve Mitnick** was the CEO of the New York-based transmission development company, Conjunction LLC, founded in collaboration with three utilities. The Empire Connection project attempted to build a 500-kV DC underground cable from upstate New York to New York City mainly along a state right-of-way. Despite broad environmental, community and financial support, and regulatory approvals, the lack of support by the state's governor ultimately brought the project to a halt.



A crew trenching a street for an underground line.

connect these two points with overhead or underground. Rather, the decision facing utilities these days is far more commonly, should we convert the connection between two points from overhead to underground.

Therefore, and this is such a critical point to understand, it doesn't matter that the installation costs of undergrounding are x number of times more costly than overheading. Typically, a distribution line under consideration for undergrounding is already in operation as an overhead. What does matter is how the installation costs of converting that overhead to underground compare with the risks and costs of the overhead failing and falling in extreme weather. Including the resultant disruption to the life and well-being of the local community.

Once one understands that selective undergrounding is all about converting some overheads to undergrounds, then our focus shifts, as it should, to how have innovations in undergrounding broadened the number of potentially attractive underground projects for a utility's customers? That is, to what extent have innovations made such projects more beneficial, whether from improvements in underground installation costs, installation time/community inconvenience, operations and maintenance costs, reliability, resilience, regulatory policy, and analytics (to select the most beneficial overhead to underground conversions)?

Underground conversions have become significantly less costly to install. The innovations have come in both the materials

As we have experienced the effects of innovation in all aspects of our industry, so too has innovation revolutionized the conversion from “overheading” to undergrounding.

of underground cable systems and the methods for emplacing them in the field. Material science deserves much of the credit. So too does cable design. As does enhancements that every aspect of the construction industries have embraced. Especially the use of prefabricated components that are trucked to a work site, simplifying on-site work, and reducing the required skilled and unskilled workforce there. It's cheaper and faster.

There have been major advancements in the semiconducting and insulation materials of cables. Not only have these cut costs directly but the product of the advancements includes longer useful life, to as much as a hundred years, larger reels, reducing the number of manholes, splices and terminations, and greater water resistance. Indeed, on that last point, I was fascinated to learn that modern underground cable systems are essentially fully submersible and thus capable of withstanding flooding.

In cable design, the amount of the conductor copper that

is used has been cut. This not only substantially reduces cost, but it also improves power transmission performance by better controlling a cable system's heating. Likewise, the adoption of cross-linked polyethylene cable jackets and range-taking shear-bolt conductor connectors have made a big difference.

Operations and maintenance costs were already moderate for underground cable systems. That's always been an advantage of undergrounding (which doesn't for example require overheading's intensive vegetation management programs). But critics in times past have pointed out, justifiably, that when an underground system does need attention that can be costly. But the application of sensors and sensor data analytics means that problems in modern cable systems are now pinpointed and far more easily addressed.

These and other innovations have made undergrounding even more reliable and resilient, absolutely and in comparison to overhead wires, for a broader range of environmental and operational conditions and events, and for a longer useful life. But what I find most interesting are the innovations in regulatory policy and analytics.

Just as the regulatory world recognized that modernization of the aging networks of the water and natural gas utilities (an imperative for customer and worker safety and environmental quality), called for a multi-decade program to smooth any impact on customer rates and to facilitate regulatory oversight of the work, it's become better understood that the same approach should apply to modernization of electric distribution networks. Even the selective conversion of overhead wires to underground cable would be a large expense for any utility. But if spread

over two or three decades, this might become manageable for utility customers.

Lastly, analytics have arrived here too, in a utility's planning of undergrounding and in the review of utility proposals by regulators. In my interviews of experts around the country, I heard stories about analyzing as many as a hundred years of detailed weather data in depth to model and determine where an undergrounding conversion would have the most beneficial impact on customers.

The selective conversion of overhead to underground would be a large expense for any utility. But if spread over two or three decades, this might become manageable for utility customers.

The innovations of undergrounding have a special meaning for me. Not long ago, the local utility in the Washington D.C. area where I reside and work was poorly perceived by the public, with a high frequency of electric service outages, which were occasionally lengthy. With the support of utility regulators, Pepco Holdings invested approximately a billion dollars in a comprehensive conversion of overhead wires to underground cable. The impact on reliability has been marked and the rate impact has been minimal, as had been the construction disruptions. Thanks Pepco. ○

Les Carter

Dominion Energy

PUF's Steve Mitnick: What's the overall strategic mission of this program?

Les Carter: The idea behind this program is to reduce the total length of restoration from specific storms, from any kind of catastrophic event. That's the objective. That's what we looked at when we were planning this program in 2013.

We were asking, what's the best way of doing that? The best way is to find the most outage-prone zones and put them underground.

If you've ever worked storm, and I worked storms in the early and mid-2000s, you know where to go. You go back to the same places every time.

It's big trees. It's single phase. It's old infrastructure. You go back time, after time. The only answer that makes sense is to

put it underground. We place it underground, and we usually bring it front lot, but not always.

When we were looking at the statistics around our single-phase overhead in Virginia, we identified that roughly four thousand miles, or about a fifth, accounted for almost two-thirds of our outage events.

We thought, if we could underground those four thousand miles, what would that do? We looked at how they performed in some earlier storms. Snowmageddon and Hurricane Irene were a couple of events we looked at. We figured out don't look at the customer restoration curve, but the work request completion restoration curve, which is different.

You see most of the tap lines we were going after would be repaired in the last half of the storm. You're doing the emergency

services first, then main lines. Then you'd get to the tap lines and the end of the line stuff in the second half of the storm.

We looked at that and said, if we could stop these from going out, and some do get restored in the first half, but most get restored in second half. If we could stop it, we could in theory, if the storm went to the right geography, which is where we had converted most tap lines, reduce the storm restoration time by up to fifty percent.

We have experienced storms since we started doing this and we're trending in that direction when we do a post-mortem on the storm. Our aim is to convert four thousand plus or minus miles of single-phase overhead.

Some multi-phase is coming in now. In Virginia, we're closing in on halfway to the four thousand miles. We will have two thousand miles converted in about June of next year. Four thousand miles would take us until about 2029; we're currently doing close to three hundred miles a year

PUF: How is it going in terms of the newer equipment, and with newer methods in undergrounding?

Les Carter: First of all, we use directional drilling. We don't trench. We directional drill, install conduit and pull cable through. That does add to the cost.

From an innovation perspective, when we were planning this, it was important for us to step back from the way we had done business in the past. We used to send designers out to get easements. That's not their core competency.

We created a new job at Dominion Energy. We have Marketing and Communications Coordinators, MCCs, and it's that person's job to be the touch point between the customer and Dominion Energy.

The MCC's job, in part, is to facilitate easement acquisition. These people do a fantastic job. When we think about innovation in terms of this program, the number one thing is making it customer centric, because if you don't have the customers on board, you have no program.

We still cancel between twenty to twenty-five percent of our projects mostly because we can't get easements. Now and again, there's a technical or operational issue you can't resolve, but it's mostly easements. Dominion Energy used to obtain roughly two thousand easements on an annual basis, however we have secured way over fifty thousand easements since we started in 2014.

The second, when it comes to innovation is how we got the program off the ground quickly. In 2011 and 2012, we had two big storms. Hurricane Irene and a derecho. When I was working those two storms, I would be in the system storm center.

The system storm centers are crazy from four in the morning until about eight or nine. Then it goes quiet until about four in the afternoon and then gets busy until eight or nine in the evening. During that time, you're sitting, monitoring what's going on. We

would talk about, if the big one came through, and we rebuilt this all again, how would we rebuild?

On the second storm, Marla Decker who used to be the Commonwealth Secretary for Public Safety, came to our storm center. She asked, what would it take to accelerate restoration? I said, if we could underground a bunch of lines, we could take the nine-day storm and make it into a five-day storm.

She suggested working with the legislature to pursue the concept. I said, that sounds like a great idea. I didn't think more about it, but there were people there who did.

In the 2013 general assembly, we started to talk about it. Then at the 2014 general assembly, a law passed that said we could implement a program and file for a rate adjustment clause.

Then a couple of years later, we had to revise it a bit in order to make sure we put some guardrails around cost, which was something the State Corporation Commission and the Attorney General's office were interested in seeing, and that's fine.

The idea behind this program is to reduce total length of restoration from specific storms, from any kind of catastrophic event. The best way is to find the most outage-prone zones and put them underground.

We came up with a metric where we said, what we're trying to do is drive events off the system. We're not necessarily trying to reduce SAIDI, the System Average Interruption Duration Index. It will happen, but events on the system are the problem.

You have to have a customer count element to it. If you are just going off the SAIFI, the System Average Interruption Frequency Index or frequency, our viewpoint is, if we have to roll a truck out to a location for one customer or thirty customers, it's still a truck roll.

Thirty customers out are worse than one, but we take care of that in our restoration process anyway, by going after the big customer numbers first. For strategic undergrounding we often have six to eight customers on a zone, not big numbers.

We decided to rank by events per mile. If you had a mile long tap and it had ten events in a ten-year period, that's ten events per mile. If you have a half a mile and it has ten events, then you get twenty events per mile.

The reason we did that partly was in order to make sure where we undergrounded gave the most bang for your buck in terms of event reduction. This is simple math, but a lot of people struggled with this. I would ask, if I have a one-mile zone that has fifteen outage events on it, or I have a half a mile zone that has ten events on it, which one should I do?



Dominion at work undergrounding transmission lines using boring.



The answer is the half a mile.
We take the other half a mile cost that you're not doing and go find another one that has ten events. Now you've done twenty events and not fifteen. All of our tap lines and protection zones

have an events per mile score. In the legislation, it calls for subsets to aggregate to nine events per mile or more, and that's an event count over a ten-year period.

In almost every one of our filings right now, we've been around

fourteen. So, we're well ahead of that number. Events per mile drives you to convert the most troublesome lines. Second, it drives you to convert those in the most economic fashion.

PUF: What about reliability and resilience of the undergrounding? How have these cables been performing?

Les Carter: They're fantastic. Dominion Energy has been replacing underground cable for a long time because we started putting cable underground in the sixties, and of course that cable has failed.

Twenty to thirty years is what you would previously expect in terms of life. Our expectation is that the asset life we're using in our depreciation schedules of thirty-nine years, based upon new materials and installation practices, is about right.

In terms of performance, if you look at the SAIDI, SAIFI, CAIDI prior and post, there's no comparison. You've got SAIDI numbers that are up over three hundred minutes, and you convert and for the same customers, you have SAIDI numbers that are around one minute. There's no comparison.

One important point is about the difference between local and system wide benefits. That's been hard to pin down. Mark Christie, former Virginia SCC Commissioner said, it stands to reason that if you convert a line to underground, there'll be fewer outages. Nobody's disputing that.

The dispute comes around whether or not there are other advantages for customers who've not been converted to underground or who were already underground, because we are socializing the cost on everybody's bill.

If we don't have to send resources to some lines, they're going elsewhere. Are you going to maintain the same set of resources on your system during catastrophic storms that you would otherwise? Even though we've done strategic underground and other reliability programs?

Yes, in storms you beg, steal, and borrow resources from anywhere you can. The reality of storm restoration is we don't skimp on resources. We're looking at it saying, we are going to obtain as many resources as we possibly can to get the power back on as quickly as possible, without regard to any of the programs we've done.

Those programs, in a world where we have equal resources, will have an impact because there is not as much work to do. If you have twenty-five percent less work, it takes twenty-five percent less time, all other things being equal.

The benefits that accrue to other customers, either those who are still overhead or those who were underground prior, is that their lights will come back on faster, or they won't go out. But mostly, their lights will come back on faster.

PUF: For the companies that have not started undergrounding, what advice would you give them?

Les Carter: I'd tell them to call us. We sat down with Duke, Pepco, Georgia Power, FP&L, Tampa Electric, and San Diego



When we think about innovation in terms of this program, the number one thing is making it customer centric, because if you don't have the customers on board, you have no program.

Gas and Electric to name a few. Some of them have said, it's interesting, but our regulatory compact doesn't help us. Some, like Duke, have implemented their own similar program.

The customer is critical. If we have a large project, we're going to have an introduction meeting, a pre-construction meeting, we're going to walk their property, and tell them everything we're doing.

We've come up with an augmented reality app on our iPads, and when we have to talk to people about siting transformers, we can take the iPad and virtually put a transformer in the picture. It is geospaced in the sense you can be in someone's front yard, and put that transformer in. Then you go inside that house, stand by their kitchen window and say, this is what it's going to look like from here.

When you make it more customer-centric, you open yourselves up to having those conversations. But also, we've changed routes because we've sat down with customers and they've said, how about you take it over here. Sometimes we'll say, we can do that. If you don't do the customer touch, you will not have a program. ○

Jerry Cook

Florida Power & Light

PUF's Steve Mitnick: What are some of the interesting innovations FPL is applying to its undergrounding pilot?

Jerry Cook: We will have completed more than five hundred neighborhood undergrounding projects by the end of this year as part of our pilot and we learn with each one. There's no substitute for real-world experience. As we've gained more experience, we have identified more efficient design and construction practices and learned better ways to handle permitting and contracting, traffic-control measures, and other processes that will help us with future undergrounding.

We use the latest horizontal drilling technology – directional boring and missile boring equipment – to minimize disruptions to customers' properties. Our crews also use handheld ground-penetrating radar devices to detect underground obstacles. We also try to reduce inconveniences to our customers by putting lines, where it's feasible, in public rights of way rather than private property.

We've also begun putting more smart grid technology underground to enhance reliability. FPL is already a leader in using

We use the latest horizontal drilling technology – directional boring and missile boring equipment – to minimize disruptions to customers' properties.

automated lateral switches, automated feeder switches, and other intelligent devices on overhead lines.

Now we're installing automated lateral switch technology on underground projects. These devices help us detect potential issues before they become problems and speed restoration if there is an outage.

We've also learned a lot about our customers and the best ways to communicate with them. During the early stages of the pilot in 2018 and 2019, we conducted a lot of face-to-face meetings with community groups and individual customers to explain the program and answer their questions.



FPL uses directional boring to minimize disruptions when installing underground power lines in its Storm Secure Underground Pilot Program. When complete, FPL restores property to its previous condition. This is in Hialeah.



A crew works on a transformer in a neighborhood in Tequesta, Fla., as part of FPL's Storm Secure Underground Pilot Program.



Extensive customer outreach, in-person or virtual, is a key component of FPL's Storm Secure Underground Pilot Program. This meeting was in 2019 in Palm Beach Gardens.

But COVID-19 pushed us toward more videoconferencing and electronic communication – even things like e-signatures and e-notaries for easements and junction box agreements, which turn out to be more efficient than paperwork.

PUF: How have these innovations affected cost and reliability?

Jerry Cook: It's hard to single out any one big innovation. There are probably two dozen things we've learned, developed, and refined during this pilot that have improved efficiency and reduced costs.

As far as reliability, we have seen that underground lines are far more reliable than overhead lines, both in severe weather and under blue-sky conditions. During Hurricane Irma, underground neighborhood power lines performed eighty-five percent better than overhead lines. During day-to-day operations, underground lines are more than fifty percent more reliable.

PUF: What has been the response to the pilot by customers and other stakeholders?



A crew feeds conduit as part of a Storm Secure Underground Pilot Program project in Sarasota.

Jerry Cook: Customers have been overwhelmingly positive. Before we begin any digging, we do extensive customer outreach so people understand what we're doing and how it will benefit them. We give them an opportunity to ask questions and raise any concerns.

We work with people on the location of pad-mounted



transformer boxes and other concerns they may have. Some people are hesitant to have a transformer in their yard.

To help address that, we have an augmented reality tool we can use so customers can visualize how the transformer will look on their property. The boxes are usually twenty-six inches tall and not as obtrusive as people fear.

Once we begin construction, in addition to minimizing disruptions to each customer's property, we emphasize to our crews the importance of being courteous and professional. When the construction is done, we restore the property to its original condition or better.

We've had customers tell us it's like we were never there. After

the underground service is connected, customers appreciate the improved reliability.

For example, there's a customer in Martin County whose lines were put underground more than two years ago, and he has sent a couple of emails since then just to thank us because his lights stayed on when a storm went through that might have caused outages in the past.

PUF: How is a particular project selected, designed, and undertaken?

Jerry Cook: One of the most common questions we get is from people who see other communities benefiting from undergrounding and ask, how can my neighborhood become a part of the program? We get asked that by homeowners and elected officials.

We select neighborhoods for the pilot based on data – outages during Hurricanes Mathew or Irma; a history of vegetation-related service interruptions; and other reliability metrics. Our work plan is approved each year by the Florida Public Service Commission. So, a community can't lobby FPL to get moved up the list, even though many would like to.

We've been selecting projects based on reliability data for each neighborhood power line or lateral. We chose that approach so we could get experience working on a wide variety of projects throughout our service area, even though we knew that working on one lateral over here and another one over there isn't always the most efficient way to mobilize and demobilize crews and equipment.

Now we are beginning to evaluate the data based on main power lines or feeders, each of which supplies power to multiple laterals. With the feeder-based approach, we expect to improve efficiency because crews will be able to focus work on a more concentrated area at a time.

PUF: What are the benefits in terms of resilience?

Jerry Cook: After the historic hurricane seasons of 2004-05,

FPL set out to build a stronger, smarter, more storm-resilient energy grid for our customers. Undergrounding neighborhood power lines is one piece of that, along with strengthening transmission structures and main power lines to withstand stronger winds; increasing our pole inspections and tree trimming; adding flood-protection measures at substations; and installing more than a hundred and seventy thousand intelligent devices along the grid.

We've seen impressive results. Because of the hardening program we began after Hurricane Wilma in 2005, we were able to get people's lights on much faster when Hurricane Irma hit in 2017, even though Irma was a bigger, more powerful storm. The average customer outage for Wilma was 5.4 days but for Irma it was only 2.1 days.

We have an augmented reality tool we can use so customers can visualize how the transformer will look on their property. The boxes are usually twenty-six inches tall and not as obtrusive as people fear.

These hardening measures also provide benefits in good weather. Our day-to-day reliability has improved nearly forty percent since 2006 and last year FPL ranked best in reliability among major utilities in Florida. We also won the national ReliabilityOne award from PA Consulting for the fifth time in six years.

Because we have a culture of continuous improvement at FPL, we're never satisfied and are always looking for ways to improve service to our customers while keeping bills below the national average.

That's how the neighborhood undergrounding pilot started.

Even though we had that big improvement in restoration time from Wilma to Irma, we saw that we could do more.

The leading cause of outages during Irma was vegetation blowing into overhead power lines. Putting more power lines underground provides a direct reliability improvement for the people who get undergrounded. It also benefits all our customers because it reduces restoration time for everyone.

We've learned a lot from this undergrounding pilot over the last three-plus years. As we continue to bring the benefits of undergrounding to more of our service area in the years ahead, we will keep leveraging technology and improving and becoming more efficient to benefit our customers. ○



Jaclyn Cantler and Donna Cooper

Pepco

PUF's Steve Mitnick: What's been Pepco's experience in selective undergrounding?

Jaclyn Cantler: I'm the vice president of project and contract management for Pepco Holdings, which includes Pepco, Atlantic City Electric, and Delmarva Power. At Pepco, particularly in the District, we have a long history with underground feeders.

Half our customers in D.C. are served by our underground system. It's a robust network system, so we've had a lot of experience. We've coupled that experience with a large program called D.C. PLUG – District of Columbia Power Line Undergrounding – where we are undergrounding up to thirty feeders within the District.

It's through a partnership with the District Department of Transportation or DDOT and D.C. government. We're excited to use our history here and move forward with this project.

Donna Cooper: I'm the Pepco region president. The undergrounding of additional feeders for the District of Columbia had been a subject that has come up intermittently.

This was not a project related to aesthetics. It was about resiliency and reliability. The poles continue to be needed for telecommunications and other infrastructure that is attached.

– Donna Cooper

Then we experienced the derecho in 2012. We had so many customers impacted across the region, with customers experiencing multiple day outages.

That event furthered the need to increase the resiliency of our system. About three-quarters of our infrastructure is underground in the District of Columbia. However, it's largely the downtown footprint.

We have Wards three, four, five, seven, and eight, which are similar to districts in other areas that are served by overhead feeders, primarily. These are the communities where many residents live.

We also have a large tree canopy. The 2012 derecho and its strength brought down many of our power lines and transformers, and trees toppled our infrastructure.

Following that event, we came together with the District of Columbia government. The Mayor called on Pepco to partner with the District and we committed our resources within engineering, operations, etcetera, to work collaboratively to develop a plan.

Our president and CEO co-led the Task Force with the City Administrator. The focus was on making our system more resilient in the face of increased weather events, with an emphasis on undergrounding electric power lines. The District of Columbia Power Line Task Force worked collaboratively for over a year to reach consensus on an approach to undergrounding power lines.

PUF: What were the benefits for Pepco customers? How was the response by customers and other key constituencies?

Jaclyn Cantler: We're taking these overhead facilities and putting them underground. The facilities

Pepco crew installing cable underground.





Pepco at work underground.

We have tailored our project schedule to coordinate with other work going on as much as possible in an attempt to reduce the impact.

– *Jaclyn Cantler*

that will be placed underground are what we call the primary overhead conductors, which can include multiple conductors along main roadways and individual or single conductors that branch off as laterals.

By placing them underground, there's less of an impact when major storms hit. The overall result has been positive. The project's inaugural feeder is one hundred percent complete and in service as of the end of 2020.

You're going to see much improved reliability at the end of this six-to-eight-year program. Our community relations, and government and external affairs group are actively involved in the effort.

Because clearly when you're working in the street, it can be disruptive. We have focused on making sure we have a solid customer and stakeholder engagement strategy.

We're keeping customers informed on when we're going to be in their neighborhoods, and what to expect. That outreach has helped them understand that, while there may be community impacts as we go through construction, the improved resiliency and reliability is worth it.

PUF: Talk about the reaction of customers, and other constituencies too.

Donna Cooper: We had diverse stakeholders at the table to

move this initiative forward – the Office of the People's Counsel, Public Service Commission, key District agencies and departments, residents, the Council of the District of Columbia.

We collectively filed a customer education plan with the Public Service Commission of the District of Columbia, which is transparent and ensures that our customers are aware of the initiative, its purpose and benefit.

The plan also outlines actions to engage customers throughout the project. It looked at milestones regarding the project, and how we can effectively communicate. We are adhering to that, as well as adjusting as necessary based on experience.

You will receive feedback from the communities, and we must always have a process in place to mitigate any concerns that may arise. We have a mailbox that is monitored and a process to ensure timely responses.

We execute community meetings and open houses to provide updates on the project and to receive customer and community feedback. Due to COVID-19, these meetings are executed virtually.

PUF: People in the communities felt that this project is protecting the trees. Because beforehand, there was a lot of, why are you cutting back our beautiful trees?

Donna Cooper: Vegetation management is important to



The model selected, addressed the cost of undergrounding that is often too prohibitive. This construct has been successful and is something others should examine.

– Donna Cooper

ensure there is appropriate clearance between trees and power lines. Undergrounding power lines helps to mitigate tree limbs from coming into contact with the lines that deliver service to customers. This helps to prevent and decrease outages.

This project will not result in all lines being placed underground because the methodology focuses on those lines that have had the highest number of outages, considerate of the impact of weather events, as well on outages. Therefore, we will continue to manage the infrastructure and appropriate clearances in areas that continue to have overhead infrastructure or partial underground infrastructure.

However, we have arborists who are committed to vegetation management practices that adhere to standards and codes. We work with our local forestry departments as well.

But we have arborists who are committed to working with our local agencies.

We've always executed our work in a way that is responsive and recognizes the importance of protecting the tree canopy, as this is critical from an environmental perspective.

PUF: This area for a major undergrounding project, of relating to communities and different constituencies, that's a key innovation?

Donna Cooper: One of the things we had to underscore, because we mentioned community, and this triggered it for me, was that this was not a project related to aesthetics. It was about resiliency and reliability.

Therefore, questions do arise. Will poles be removed? In many cases, the answer is, no. The poles continue to be needed for telecommunications and other infrastructure that is attached.

Education and engagement are key to ensuring that our customers and communities are aware of the actual scope of the project and its purpose. When we have the opportunity to engage, there is always greater understanding from our customers and communities.

Jaclyn Cantler: When we talk about the benefits of the partnership among Pepco, the District, and DDOT, we also looked at what other projects are happening at the same time. We have tailored our project schedule to coordinate with other work going on as much as possible in an attempt to reduce the impact.

There's a lot of thought that goes into it, and having those three entities at the table, communicating about current and future plans, helps to make the impact of all this construction more streamlined.

PUF: What innovations in undergrounding were helpful? Talk

about some of these technical issues that matter in terms of how fast you can do it, cost, and reliability.

Jaclyn Cantler: Our number one priority is safety. On the innovation space, we're deploying equipment underground that we can work with from above ground with specific tools.

These are special transformers that are being installed underground, and you can work on them from above. They require less maintenance, so you don't have to address them as frequently as you would overhead facilities.

A person can stand on the street with a hot stick and intercept a piece of equipment, which goes to making sure our solutions are promoting safety. Due to less maintenance, you're putting workers in the line of danger less frequently.

We also leverage fault detection devices, which can help expedite the troubleshooting when there is an interruption associated with an underground facility. We're leveraging all of our experience with our extensive underground system in this new program.

PUF: Talk about the policy innovations.

Donna Cooper: That was one of the first unique aspects about this project, is that it is enabled through legislation. There are various policy interests outlined in the legislation.

There is a focus on advancing economic benefits; contracting opportunities for local and diverse business enterprises; employment opportunities for local residents and affordability.

The Task Force also advanced equity regarding undergrounding power lines, meaning equity regarding the number of power lines that would be underground in each ward. The methodology ranked the feeders based on performance as well as equity.

The financing construct was also critical. There is a fifty-fifty construct, with resources advanced by the District of Columbia Government and Pepco's traditional debt/equity structure.

This construct, along with the amortization period, resulted in the initiative being more affordable for customers. We had to answer the questions: How do we execute a project to achieve meaningful outcome, while not resulting in significant costs to customers? What is the best framework? We had to consider multiple variables.

All stakeholders recognized that significant weather events result in extended outages, and this is a cost to residents and the District. It was clear for all parties that the benefits of the final plan outweighed the costs, as there are losses when you have an outage.

The model selected, addressed the cost of undergrounding that is often too prohibitive. This construct has been successful and is something others should examine.

PUF: What advice would you offer to utilities around the country as they consider undergrounding projects?

Jaclyn Cantler: Importance of participation by all impacted entities, and stakeholders that were included – the District,

DDOT, and business owners. Everybody having a seat at the table. It's what is helping this program be successful.

This is one of the many investments we've been making in Pepco over the years since the derecho to make the system more reliable. We increased our reliability of the system over the last ten years by about sixty-eight percent.

That's just not a product of putting facilities underground, it's also installing auto-sectionalizing devices, and upgrading aged equipment. In 2020, Pepco had the best reliability year ever. On average, we see about one outage per customer a year now in Pepco, based on reliability improvements we've been investing in.

Donna Cooper: Every utility is making investments in, and upgrading infrastructure, so there needs to be a hard look and evaluation of the of the upgrades they're making, and how their system is performing, as well as the vulnerabilities they have identified.

Everybody having a seat at the table. It's what is helping this program be successful.

– *Jaclyn Cantler*

These entities have their independent data and they also receive feedback from their customers, the Commissions, and other interests. As a regulated utility, we report on system performance and there is ongoing evaluation regarding plans to improve reliability and resiliency.

A question that is consistent is, what more can be done to improve service to customers? Utilities have to respond to the questions. What is that more? Is it undergrounding? What is the cost? What are ways to mitigate the impact? Does the cost outweigh the benefits?

Climate change is real, and we're seeing more significant weather events. It's not a matter of whether we will experience significant weather events, but a matter of when. We have to ensure, as utilities, that we are providing the highest level of service to our customers and balancing costs.

With increased weather events, we must have a focus on resiliency. Therefore, engaging multiple interested stakeholders, with our customers being foremost, is critical. We must build partnerships, share information, and make informed decisions, collaboratively.

For other utilities, it's bringing stakeholders forward and into the planning process. It's being proactive, advancing where there are vulnerabilities, and building partnerships to advance plans to ensure resiliency.

Too often, we will come together during an event, and after the event, the planning ceases. It requires a commitment after the event passes. ○

Rajdeep Roy, Thuan Tran and Angel Brito

Southern California Edison

PUF's Steve Mitnick: What are some of the experiences you've had or projects with selective undergrounding?

Rajdeep Roy: While there are many different reasons why electric companies underground power lines, I'd like to focus on targeted undergrounding for wildfire mitigation.

For us in California, wildfire mitigation has been one of our top priorities as we face increasingly extreme weather conditions. We have a portfolio of system hardening strategies to make our overhead power lines more resilient to wildfire risk, including targeted undergrounding and replacing bare wire with insulated wire, which we call covered conductor.

I mention covered conductor because, considering SCE's diverse geography and terrain, it is currently the best mitigation that can reduce the greatest amount of wildfire risk in the shortest amount of time at the most affordable cost for our customers.

Much of our high fire risk areas have rocky, granite terrain.

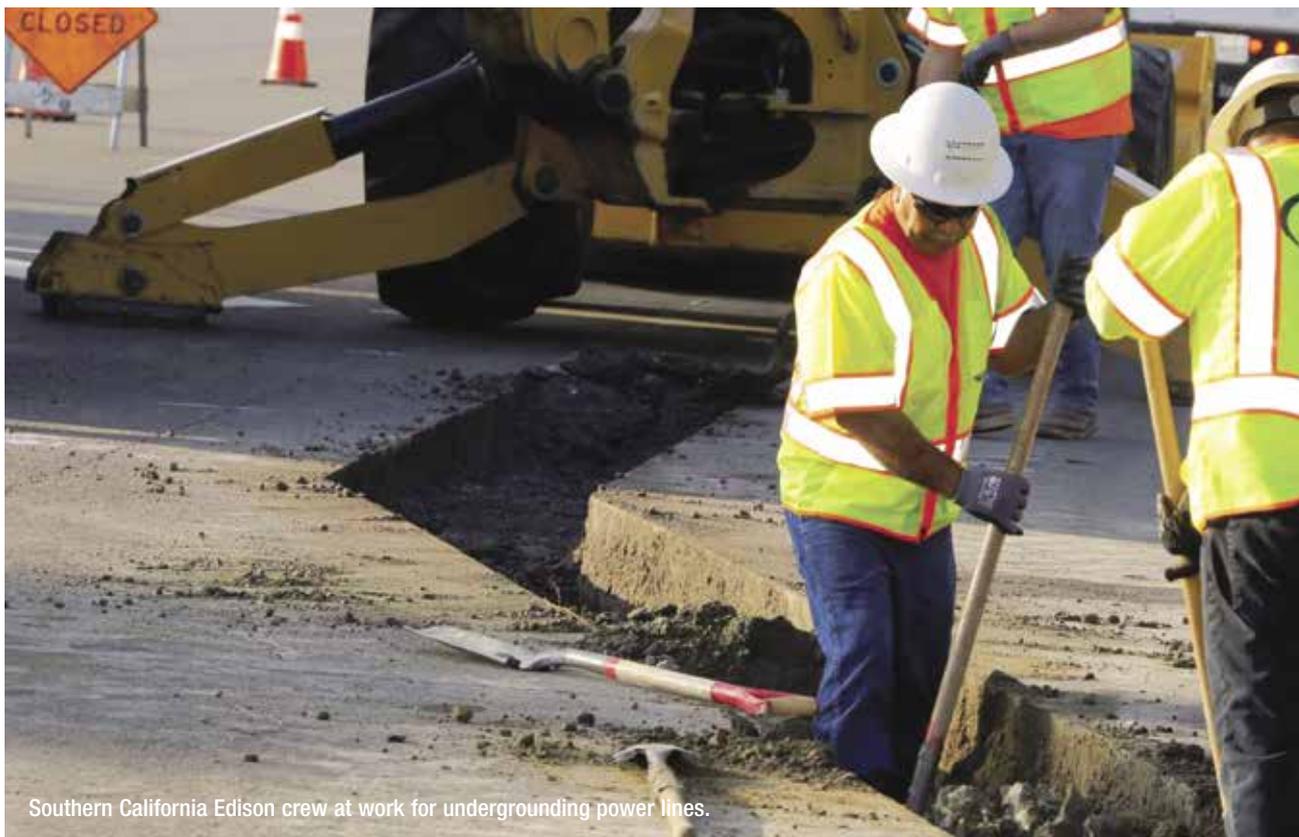
California has diverse weather, topography, and vegetation. Utilities serving each region of the state have to take customized approaches to wildfire mitigation.

– Rajdeep Roy

When you have power lines that go over mountains, undergrounding those lines can sometimes be infeasible.

Also, converting overhead to underground lines can result in longer lines and higher costs. Often times, overhead and underground lines cannot travel along the same routes, resulting in additional routing that extends the length and higher cost per mile for the overhead line replaced.

California has diverse weather, topography, and vegetation.



Southern California Edison crew at work for undergrounding power lines.

Utilities serving each region of the state have to take customized approaches to wildfire mitigation.

The biggest driver of an ignition risk we see on overhead lines in our service area is contact from objects, and covered conductor is estimated to be about seventy percent effective in mitigating this risk. We complement this effort by inspecting our highest risk structures more frequently and managing trees and vegetation around our poles and equipment, so they don't grow or fall into power lines.

When overhead lines are placed underground, the type of construction involves longer lead times and more resources, reducing the amount of infrastructure that could be hardened within the same timeframe compared to installing covered conductor. While there's incremental risk reduction, you still have that additional remaining risk every year that covered conductor could have mitigated earlier.

2020 was a record year for wildfires, and this year has already seen more acres burned than last year to date, which is a direct effect of climate change. This requires urgent actions to reduce the risks that are increasing each year.

However, targeted undergrounding does have a role to play in our portfolio. We focus on areas where we believe covered conductor wouldn't sufficiently mitigate the wildfire risk. Considerations for undergrounding include locations that have limited egress or ingress, areas that experience extremely high windspeeds and are subject to frequent Public Safety Power Shutoffs, areas with a lot of high density tall trees, and/or areas where risk of overhead conductor failure is primarily from factors other than contact from objects. Our targeted undergrounding strategy continues to evolve and may lead to additional locations in the future.

Thuan Tran: Based on our current risk analysis, undergrounding is estimated to reduce about ninety percent of wildfire risk,

while covered conductor is estimated at about seventy percent.

There are two ways of undergrounding – installing underground cable in new development areas or converting existing overhead lines to underground cable in established neighborhoods, which is more challenging.

To gain significant mileage of undergrounding conversion, we are looking at ways to transform our undergrounding methodology, standards and construction methods, and incorporating new technologies to help improve deployment speed and affordability.

Angel Brito: Under Rule 20, we've been working with communities on undergrounding projects for both aesthetic and non-aesthetic purposes, such as new demand growth.

Based on our current risk analysis, undergrounding is estimated to reduce about ninety percent of wildfire risk, while covered conductor is estimated at about seventy percent.

– Thuan Tran

In 2019, we began targeting specific areas that would benefit most with undergrounding for wildfire mitigation purposes. This year is the first year we're starting construction for the projects that we began scoping in 2019. We plan to learn from this initial deployment and incorporate lessons learned going forward.

There's typically about a twenty-four- to thirty-six-month lead time for undergrounding projects, depending on the topography, local jurisdiction, permitting and other factors that play into the cycle times.

To be able to convert to undergrounding quickly, you not only have to deal with the construction but also permitting and potential environmental requests.

PUF: There's been much learning at your company and throughout the industry to where these methods are more reliable and cost-effective. Talk about those.

Rajdeep Roy: Even with targeted undergrounding, we want to see if there's a more appropriate way to do it and if there are technologies that are available that can facilitate faster deployment.

For many years until the early 2000s, we used cable-in-conduit. That was our undergrounding standard, where you're pulling cable with the conduit, trenching and installing at the same time.





Southern California Edison crews doing undergrounding work on Lambert Road.

There's typically about a 24- to 36-month lead time for undergrounding projects, depending on the topography, local jurisdiction, permitting, and other factors that play into the cycle times.

– *Angel Brito*

We realized over the life of that technology that there are potential reliability issues when you just lay the equipment in the ground. It can bend among the rocks and soil and be susceptible to dig-ins. When faults occur, it can be difficult to locate the issue and result in longer outages because the underground cable is not secured like our current standards.

Our engineering team benchmarked with other utilities at that time and decided to pivot. We transitioned to rigid conduit with duct bank construction. The duct banks are enclosed in concrete encasement with conductors pulled through the PVC conduit, which makes it sturdier. Every so often, we have structures, manholes or vaults where we can get in after a fault occurs, pull the cable out, and put a new one back in.

Compared to the longer underground cable segments with cable-in-conduit, the shorter segments with duct banks makes it easier to identify faults, resulting in shorter outages and better reliability. That being said, some time has passed and that is why we are benchmarking again with other utilities on the latest technology and methods to underground our infrastructure.

PUF: Thuan, for benchmarking, as you're looking around for advances around the country and best practices, what are you finding?

Thuan Tran: From an engineering perspective, we benchmark nationally and internationally.

We went as far as Australia, Europe and East Asia to learn about their construction methods and standards for covered conductor. Then we tested the technology, established our engineering and construction standards and continue to monitor the system and make improvements from lessons learned.

For undergrounding, we're benchmarking with industry groups like EPRI and EEI and other utilities like Dominion Energy and WEC Energy Group.

We also benchmark with construction companies, suppliers, and contractors. In the last three decades, folks who built fiber optic lines have been doing the most undergrounding in the country. We are learning from the cable manufacturers, the same companies that helped us redesign the new generation of robust covered conductors.

We are learning about new technologies, including the new generation of cable-in-conduit. We will be using this learning and benchmarking to review and revamp our underground standards, the same way we revamped our overhead system standards to accommodate covered conductor.

For example, we learned that for excavation, trenching and drilling technologies, there is no one-size-fits-all approach. It's a combination of several technologies.

When you think of trenching, you typically think of using a backhoe machine. But there are additional methods and new technologies to explore. We've learned about rockwheel trenchers that can cut into most types of rock at a relatively fast speed. Horizontal directional drilling technologies that can drill under flood channels. Plowing methods that can open trench and install a conduit at the same time. We're also researching new undergrounding technologies such as an emerging drilling technology that uses plasma technology to cut through granite.

With cable-in-conduit, we've seen improvements of the thickness of the conduit material and the cable design.

For example, today's version of cable-in-conduit design uses a swellable tape under the jacket of the cable. Typically, if the jacket is broken, there's an increased chance of water intrusion

that would cause corrosion on copper neutral wires. But with the swellable tape, it will fill up the crack and impede water intrusion.

Undergrounding may seem appealing because it's, out of sight, out of mind. But it comes with challenges. It is more difficult to locate underground cable failure and perform repairs, which results in longer outage time for customers.

That's why we are exploring ways to improve how we locate underground cable faults. We're benchmarking with WEC Energy Group, a utility in Wisconsin that has been using a GPS sensor to map out their underground cable.

The sensor automatically uploads cable location data to their map and server. If the cable fails in the future and requires locating a fault, the GPS-based mapping information would help locate the cable.

Rajdeep Roy: We continue to learn from our industry peers and improve our undergrounding practices system-wide. However, I'd like to highlight that in terms of reducing wildfire risk, we have yet to find a technology solution, at least right now, that would make the undergrounding costs and deployment speed hurdles change so dramatically that we would shift away from pursuing covered conductor first before undergrounding, except for targeted locations that meet some of the criteria I mentioned earlier. ○

Dave Plusquellic

Tampa Electric

PUF's Steve Mitnick: How is your department structured to support the Storm Protection Plan?

Dave Plusquellic: The formation of the Storm Protection Plan team started in late 2019. Once we identified our goals and targets, we began building the internal team and defining the roles we needed to support those targets. The targets also allowed our contractor partners to build their teams to support the long-range goals of the program.

We started with a small start-up team with people in the roles we thought were critical for launch in 2020. We knew we would need to grow strategically throughout 2021 and 2022, and we needed time and experience to identify the most efficient structure.

In early 2021, we secured a dedicated warehouse with a full-time team. We're currently adding to our design and project management teams. Throughout late 2021 we'll be launching a full construction management team.

PUF: What are your goals with this team?

Dave Plusquellic: The goal has always been to make sure we do our absolute best to invest money wisely and cost-effectively to the benefit of our customers. Specific to SPP, it's to ensure



we're making sound investments that will result in more reliable service during extreme weather and to lower the overall time and costs associated with restoring power after those extreme weather events. We're fortunate to have this opportunity, and we're equally passionate about the responsibility that comes with it.

PUF: You have to be strategic and selective about what you're undergrounding. How did you narrow it down or determine what to prioritize?



Tampa Electric crews (above) dropping overhead lines, and (below) measuring for undergrounding.



The program required a comprehensive look at benefits versus costs, with a focus on extreme weather events, so we conducted a thorough and robust data-driven analysis.

Dave Plusquellic: Yes, you have to know what your goal is before you can start prioritizing and tackling the operational hurdle of standing up a program to bury lines. The question for us wasn't just, where do we see frequent outages?

It was focused on where are we most likely to have expensive, prolonged, difficult-to-repair outages from extreme weather events – those are the places we need to address, to provide our customers better reliability during a storm and to avoid lengthy delays and costly repairs after a storm.

The program required a comprehensive look at benefits versus costs, with a focus on extreme weather events, so we conducted a thorough and robust data-driven analysis.

PUF: Talk generally about the culture of Tampa Electric.

Dave Plusquellic: Tampa Electric's core value is safety – of employees and customers. It is part of everything we do.

In addition, it is one of the most forward-looking companies I've been affiliated with. If you look at what we've done to our Big Bend plant, where we're modernizing it by converting it from

coal to gas, if you look at our solar ambitions, we are the biggest solar generator in the state per customer.

We've also invested in projects like smart meters, or AMI, automated meters. We're doing a lot in these technical areas to advance the grid and technology. Putting that into context, the investments we're making in our system are impressive when you consider our size. We have eight hundred thousand customers and are smaller than many of our peers in the region.

The company has been supportive of the Storm Protection Plan, because once you have a certain part of the system hardened and undergrounded, it benefits all customers after extreme weather events, such as a hurricane.

PUF: How are customers reacting, and how's it going overall?

Dave Plusquellic: Overall, the customers like the idea of lines being underground, and most customers have been very positive. The biggest challenge we have is getting easements for the primary route and equipment.

We have a diverse service area. We've got some areas that are a bit more rural, and the lot sizes are bigger. Customers in these areas are generally more receptive to providing an easement.

When you go into a denser, more metropolitan area where the yards are smaller, the homes are closer together, and the area is more congested than the rural areas, it has been more challenging to obtain easements.

Our view is that the SPP is a customer experience program as much as it is a construction program. We have a small internal team dedicated to customer communications that is focused solely on how we provide the right information to our customers at the right time.

Our goal is to continually improve that process for the customer and to ensure each customer has the information they need to make the right decision about an easement on their property.

We have a small internal team dedicated to customer communications that is focused solely on how we provide the right information to our customers at the right time.

PUF: Where do you think this is going in three to five years?

Dave Plusquellic: We are about eighteen months into our Storm Protection Plan, and momentum and excitement are starting to build. We expect the project will grow to install about one hundred miles of underground lines every year. The SPP is part of our goal to create value for our customers, which we will achieve by increasing reliability and improving the customers' experience. ○

PG&E's Landmark RFI to Underground Ten Thousand Miles of Lines

'We Want Partners in Thought and Action, With Courage and Conviction'

On the twenty-second of July, Pacific Gas & Electric announced its commitment to underground ten thousand miles of its power lines to help reduce wildfire risk and address climate change. Then, on the twelfth of August, the company issued a Request for Information, an RFI, seeking approaches to what the company termed "this feat."

By the end of September, PG&E met with firms that responded to the RFI, each of which presented their approaches to accomplish this unprecedented project, and necessarily implement a range of innovations to succeed. We do not yet know the outcome of these monumental steps in strategic undergrounding, but given the importance for the entire electric utility industry, the PUF team provides herein the key excerpts of the RFI.

RFI's Purpose

On July 22, 2021, the company announced its commitment to underground 10,000 miles of electric lines beginning in High Fire Threat Districts across our service area to help reduce the risk of

major wildfires and address the challenge of climate change. The scale of our plan is unprecedented, and the strength of our commitment is unparalleled. This represents the largest effort in the U.S. to underground power lines as a wildfire risk reduction measure.

We know that we cannot do this alone – we need help. We want partners in thought and action, with courage and conviction, that will challenge us, share our commitment, and co-create what will become the country's most modern and expansive underground electric system. As such, PG&E is inviting your response to this Request for Information (RFI) to seek creative approach(es) to achieve this feat; however, this is more than just a Request for Information – it is an invitation for industry-leading Imagination, Ideas and Innovation that will provide safe and reliable energy to California for generations to come.

Participants are requested to submit four (4) elements within their response: (1) general company overview, (2) recommended approach(es), (3) response to supplemental questions, and (4) relevant project examples. Responses are due no later than 4PM

PT on Thursday, September 2nd, 2021. Information submitted in this RFI will be used to identify participants with whom PG&E is interested in furthering discussions around the proposed approaches and innovative ideas.

Thank you in advance for your interest in partnering to help us achieve this audacious and ambitious goal on behalf of our more than 5 million customers.

Twenty-Four Questions for Responding Firms

1. **Work Sequencing.** We are looking for the most practical way to mitigate wildfire risk as quickly as possible with this plan. Describe the strategy you would utilize to optimize sequencing of the work. Consider factors such as local geology, environmental, cultural, permitting, etc.

2. **Safety & Quality.** Based on your approach, what innovative safety and quality practices, management system(s) and tools would you utilize?

3. **Work Delivery.** What is your perspective on an effective structure to manage safety and quality? Please incorporate experience from programs of similar scale in your response.

4. **Cost.** Based on your approach(es), provide an estimated cost per mile range (e.g., \$X - \$X) for the below scenarios. Please include an estimated breakdown of equipment, materials, labor, OH and other cost elements: (a) optimal scenario (best results possible), (b) optimistic scenario, and (c) most likely scenario.

4a. **Cost.** Based on your response to question 1, clearly specify what conditions and elements would need to be present to enable (a) optimal scenario, (b) optimistic scenario, and (c) the most likely scenario.

5. **Cost.** Which cost model(s) would you recommend utilizing

for this program? Describe the pros and cons of each model if multiple options.

6. **Contracting.** Based on your approach, what performance-based contracting methods would you recommend?

7. **Resources.** Describe how your company and PG&E would partner to secure and maintain talent, ensuring success through the duration of the program.

8. **Resources.** Based on your approach, would you have internal

Where do you see the greatest opportunities to use innovative, commercializable technology (emerging and/or existing) to improve pace, quality, cost, or other performance of the undergrounding program?

capacity to complete independently, or would a joint venture/partnership structure be required? Please provide additional detail to support your response.

9. **Alternative Work Delivery Methods.** Describe any additional work delivery methods (not included in your approach) that you would consider in delivering this work. Describe the pros and cons of each.

10. **Application.** Have you applied any key elements of your recommended approach to work elsewhere (including in other industries)? If so, describe the general outcomes achieved and lessons learned. »

FORTNIGHTLY INNOVATORS EVERY YEAR

This is the fifth consecutive year that Public Utilities Fortnightly has asked the utilities industry for nominations for our annual Fortnightly Top Innovators and published a feature in the fall highlighting and celebrating the most distinguished individual and teams of innovators. The November 2017 issue of PUF featured for example two innovators from Ameren (Steven Ewens and Alex Rojas), one from American Electric Power (Jeff Fleeman), two from CMS Energy (Andrew Bordine and Holly Bowers), two from Edison International (Vibhu Kaushik and Erik Takayesu), two from Entergy (Randy Hickman and Shannon Watts), two from Exelon (Sonya Harbaugh and Brian Hoff), and two from Hawaiian Electric (Earlyne Maile and Lani Shinsato). And from not just investor-owned utilities, but David Ranallo of Great River Energy, Bud Ajdukovic of Kissimmee Utility Authority, Lizette Miranda of Sacramento Municipal Utility District, and several more. Plus a whopping six from the Electric Power Research Institute, quite naturally, those being Ron Domitrovic, Jessica Fox, Maria Guimaraes, Andrew Phillips, John Simmins and retired EPRI CEO Mike Howard.

The November 2018 issue of PUF featured for example Cole Crews of Ameren, Shay Bahramirasd and Sandor Williams of Exelon, Eric Mastroianni, Edwin Perez, Jennifer Moy and Mike Salerno of Con Edison, Jamie Duncley of EPRI, Rebecca Dayhuff Matsushima of Hawaiian Electric, Nicholas Jewell of PPL Utilities, Chris Spears, Catherine O'Dell and Tom Butler of North Carolina Electric Cooperatives, Brian D'Agostino, Steve Vanderburg and Katie Gianecchini of Sempra Energy, and Mark Lantrip of Southern Company.

Last year's was a distinguished class of Fortnightly innovators as well. For instance, Jessica Fox of EPRI repeated her 2017 honor with her continuing work in environmental protection. And there were honorees from PPL Utilities, Xcel Energy, Poudre Valley Rural Electric Association, First Solar, Sempra Energy, Edison International, Ameren, Hitachi ABB Power Grids, and Burns & McDonnell.

11. Equipment. Describe any specialized and/or innovative equipment (emerging and/or existing) that would drive safety, quality, and efficiency of this work.

12. Materials. Describe any specialized and/or innovative materials (emerging and/or existing) that would drive safety, quality, and efficiency of this work.

13. Technology. Where do you see the greatest opportunities to use innovative, commercializable technology (emerging and/or existing) to improve pace, quality, cost, or other performance of the undergrounding program? Please provide additional detail to support your response and incorporate perspectives from other industries in your response, where applicable.

14. Organizational Structure. Based on your approach, what leadership/governance structure would you recommend for a program of this nature? Please specify your potential role as a prime, the role of subcontractors, PG&E's role, and the role of other parties (suppliers, external stakeholders, etc.)

15. Execution. What is your perspective on an appropriately ambitious ramp up of constructed miles, by year, to achieve 10,000 miles?

16. Project Management. Based on your approach, how would you effectively apply project management practices, tools, and methodologies to execute work under this program. Include detail on project management system(s).

17. Land Rights. What is your perspective on private land rights acquisition and, in particular, how and when such activities should occur when pursuing a program such as this? Please incorporate detail from experience on other programs of similar scale.

18. Risks. What are the top five (5) risks you see in executing a program of this nature? What innovative mitigations would you use to minimize or eliminate these risks?

19. Information Technology. If applicable, describe any experience you have with the following and whether your recommended approach has considerations for the below areas. If no experience for one or multiple of the below, please indicate such. (1) Undergrounding fiber optic cables in conjunction with electric conductors / conduits; (2) Accommodating SCADA electronics and communications connectivity to underground assets; (3) Splicing and terminating fiber optic cables (underground vaults, pad mount cabinets, overhead to underground transitions, etc.)

20. Stakeholder Engagement. PG&E would like to understand your approach and experience with stakeholder engagement. Describe your approach, from an organizational perspective, toward stakeholder and community education/engagement and permitting.

21. Project Planning and Implementation. Based on your experience and knowledge of PG&E, what changes should PG&E make to how it runs, plans, and implements projects to successfully underground 10,000 miles?

22. Company Culture. In one paragraph, describe your company culture.

23. Responsibility. Given your responses above, detail how you would demonstrate your commitment to diversity and inclusion throughout a program of this nature.

24. Supply Chain Impact. Given your responses above, what would be the impact and anticipated ramp time to scale the supply chain in response to your proposed solution. Which products would likely present the highest impact (in terms of lead time) to the project schedules? Please consider the development of new technologies, and/or capacity enhancements in existing markets. [PDF](#)

AEIC Top 10 Awards 2021

(Cont. from p. 51)

storage, community generation, and grid-operability capability. There are no up-front costs for participants, who will be charged standard Tampa Electric rates.

Each of the houses will have a BlockBox unit containing battery storage, an inverter, and a controller that communicates with the other controllers on a seven-hundred-and-fifty-volt DC bus and shares energy. The system also includes a central energy box with supplemental storage and a grid interconnection.

The BlockEnergy proprietary control network is the hub of all the distributed energy resources within the system, employing the dynamic pricing model of game theory to optimize system operation. The system can operate both grid-connected and islanded resources.

Tennessee Valley Authority: Safety blitz

TVA's generation services health and safety committee developed and implemented the "safety blitz" process. Safety blitzes are a combined effort with the generating sites to drive employees' focus on the utility's 4 Vital Behaviors and to foster a safety culture.

The 4 Vital Behaviors are:

1. Identify hazards before every task.
2. Take actions to remove hazards and reduce risks.
3. Protect yourself and others. Intervene when necessary.
4. Take pride in safety and be involved.

Safety blitz observers work closely with site personnel to conduct site walk downs including observations of in-progress work. If possible, identified issues are corrected in the field when identified.

In fiscal year 2021, that ended last March, forty safety blitzes were completed. Serious and recorded injuries have fallen substantially. [PDF](#)

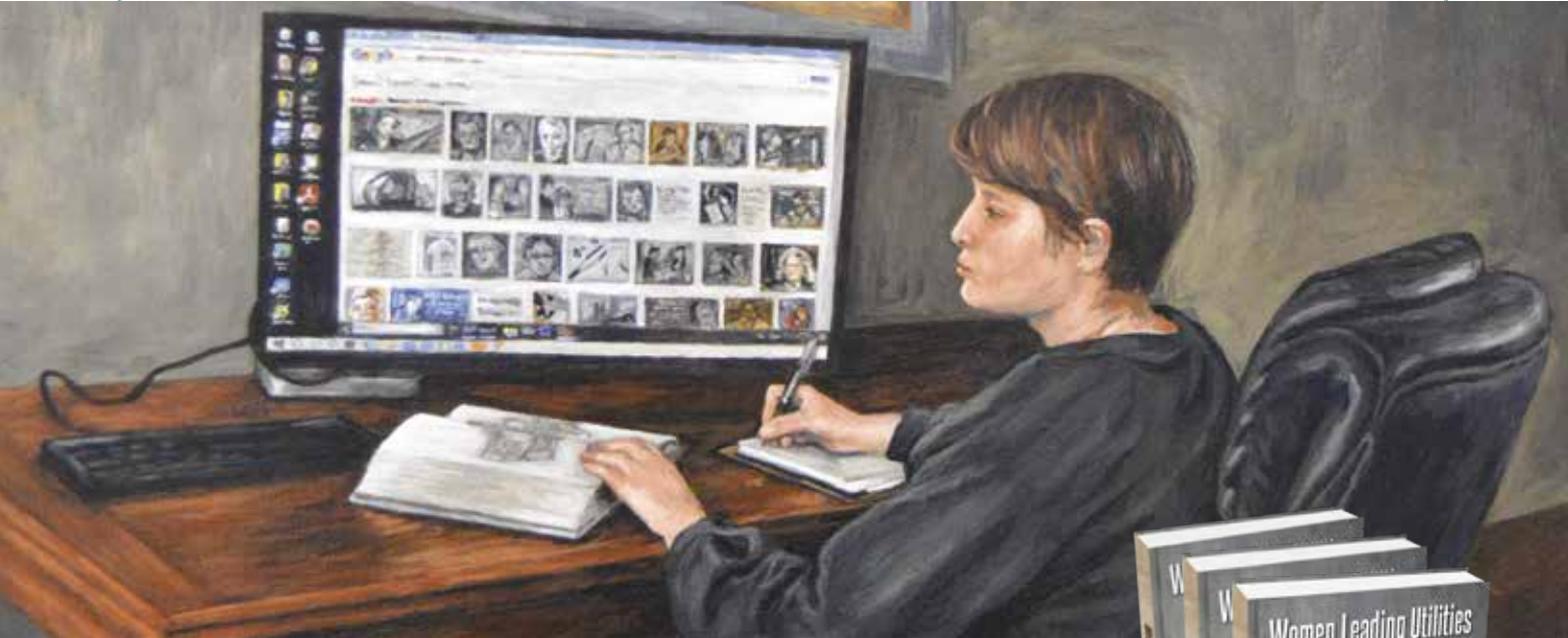
Authored by PUF's Steve Mitnick

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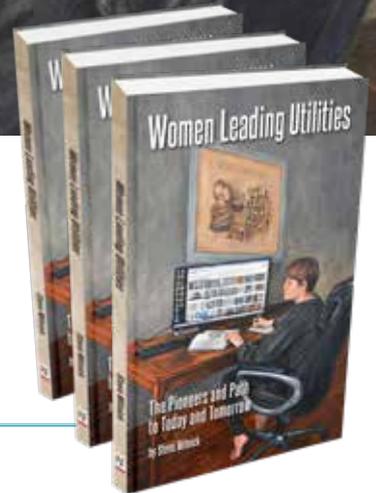
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Utilities, utility associations, commissions, professional firms, vendors, etc. may purchase a number of the beautiful hardcovers of Women Leading Utilities to provide to employees and other internal and external constituencies.

100 hardcovers at \$4,000 for example.

Contact Alex Revel for details, arevel@fortnightly.com.



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