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The Sustainable Resilient Affordable Debates

JUNE 18, 2024

The Infrastructure Imperative
Ten Commissioners Talk Infrastructure
Guidehouse Lightning Round

Special Issue
State and Future of Power

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Front cover, a painting by PUF's Paul Kjellander, "Towering Above."

The Energy Infrastructure Imperative

Giant Leaps Call for Giant Courage and Confidence

BY STEVE MITNICK, EXECUTIVE EDITOR

"We choose to go to the moon in this decade, and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one that we are unwilling to postpone, and one which we intend to win…"

This famous quote from President John Kennedy's September 12, 1962 speech at Rice University inspired a historic undertaking by the nation that succeeded in seven years. Kennedy had been briefed about the many unsolved problems, any of which could have singlehandedly sidetracked the space program. But he had courage and confidence born by the extraordinary war effort when he was a Navy Lieutenant in his twenties.

I invoke Kennedy's mission, and how it moved the nation to land a man on the moon, to remind us that we are more than capable of giant leaps for mankind, to paraphrase Neil Armstrong. When our will is summoned. When our means are mobilized.

Which is an important lesson as the nation and its energy industry in particular have been summoned once again. In this instance, to dramatically decarbonize our production of energy.

Myriad Reasons We Can Fail

Like the space program, the drive to decarbonize is encountering many unsolved problems. Each has the potential to prevent a smooth landing.

So, I want to bring up another applicable and inspiring quote, sticking with the space program, from "The Martian." The last lines of the 2015 movie, spoken by Matt Damon's heroic character Mark Watney, were:

"At some point, everything's gonna go south on you. Everything's going to go south and you're going to say, this is it. This is how I end. Now you can either accept that, or you can get to work. That's all it is. You do the math. You solve one problem, and you solve the next one, and then the next. And if you solve enough problems, you get to come home."

Steve Mitnick has authored five books on the economics, history, and people of the utilities industries. While in the consulting practice leadership of McKinsey & Co. and Marsh & McLennan, he advised utility leaders. He led a transmission development company and was a New York Governor's chief energy advisor. Mitnick was an expert witness appearing before utility regulatory commissions of six states, D.C., FERC, and in Canada, and taught microeconomics, macroeconomics, and statistics at Georgetown University.

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Like the space program, the drive to decarbonize is encountering many unsolved problems. Each has the potential to prevent a smooth landing.

Doesn't it seem, more than occasionally, this or that solution in the drive to decarbonize has gone south? For, to come home, the phrase Watney uses, the energy industry must build so much of so many things and at such a fast pace. There are myriad reasons we can fail to meet this moment.

In Their Shoes

Put yourself in the shoes of the builders, those wanting to put into place the new energy infrastructure that is needed. Then, think of all the quite formidable barriers blocking the way.

They can expect local community opposition almost no matter what the nature is of the planned infrastructure. They should also expect equally fierce opposition from national and regional groups that tend to join the fight.

When they come in for regulatory approvals, good luck there too. The burden is on the builder in every such forum. To prove that the project is needed. That it is needed now. To prove that the project price is affordable for the public. To prove all the variations and all the alternatives that could possibly meet the need are demonstrably inferior.

When called upon by the courts for regulatory approval appeals, they know the judicial decision will be anything but decisive. The legal processes may drag on for years.

The press will be critical. That's an automatic. Before long, public sentiment will turn negative. This can translate into uneasiness in the financial community upon which the builder's company, contractors, and partners are so dependent.

What They Need

I'm not saying you should hug an energy infrastructure builder. Those folks are fairly resilient. They need to be. They know to shrug off the slings and arrows of outrageous fortune.

But I am saying we should fully understand how very hard it is to win all the approvals necessary to build energy infrastructure. How the odds are stacked against those builders and their plans. How easily such plans lose momentum and funding when stalled, as opponents pile on.

Builders don't need our sympathy. But what they – and we too – do need is fact-based consideration of what they propose. Plus, a timely decision to go or no-go. That sticks. PUF

Ten Commissioners Talk Infrastructure

Conversations with Commissioners from the Arizona CC, Lea Márquez Peterson; Georgia PSC, Tricia Pridemore; Indiana URC, Sarah Freeman; Louisiana PSC, Eric Skrmetta; New Mexico PRC, Pat O'Connell; North Carolina PSC, Floyd McKissick; Pennsylvania PUC, Steve DeFrank; Virginia SCC, Jehmal Hudson; Washington UTC, Ann Rendahl; Wyoming PSC, Mary Throne.

With PUF's Paul Kjellander, NARUC President, November 2020 - November 2021.

Many demands are being placed on utilities these days, as the energy transformation continues to gain momentum. To move forward requires new thinking on the economic necessity of upgrading energy and utilities companies' aging infrastructures.

That requires new thinking on the part of regulators too, often faced with novel policies as the economic journey continues hand in hand with those subject to the regulations. Upgrading facilities, while ensuring reliability and resiliency, are issues that have gained importance.

Public Utilities Fortnightly looked for insight into these issues by bringing together ten Commissioners from varied parts of the nation. Asked of each were four questions, allowing for comparing their thoughts on what is next for infrastructure.

Those questions are: What are the most important needs for electric power infrastructure? What are your greatest concerns about infrastructure? How should utility regulation adjust to these needs and concerns, if at all? How different will electric power infrastructure be in the year 2040?

The following ten Commissioners took time from their packed schedules of regulating utilities in the public interest to respond: Pat O'Connell, Steve DeFrank, Jehmal Hudson, and Mary Throne are their Commission's chair. Tricia Pridemore is NARUC First Vice President. Ann Rendahl is Second Vice President. Sarah Freeman chairs NARUC's Subcommittee on Education and Research. Floyd McKissick chairs the Committee on Consumers and the Public Interest. Mary Throne chairs the Subcommittee on Clean Coal and Carbon Management. Jehmal Hudson chairs the Committee on Energy Resources and the Environment.

Commissioner Lea Márquez Peterson

Arizona Corporation Commission

PUF's Paul Kjellander: What are the most important needs for the electric power infrastructure?

Commissioner Lea Márquez Peterson: Arizona is interesting because we are growing so rapidly. We're one of the fastest growing states in the country.

We have aging infrastructure that needs to be replaced and then the need for more transmission. We've had some controversial issues related to new lines coming into our state over the past several years.

PUF: What are the greatest concerns with infrastructure and for dealing with that?

Commissioner Lea Márquez Peterson: In our case, related specifically to transmission, it's NIMBY. Nobody wants that built into their backyard. We have a transmission line case called SunZia – probably a lot of people are familiar with it – that took a decade-plus to get approval.

I was on the Commission when we approved it. It's now being appealed by some of the tribal nations in the area.

When you negotiate the right of way based on the energy load needed in the state, but then look at the human and environmental impacts, it becomes a controversial issue to try to develop and fund transmission lines in a timely manner. We have a challenge with transmission across the west and that is top of mind for us in terms of infrastructure in Arizona.

We have a challenge with transmission across the west and that is top of mind for us in terms of infrastructure in Arizona.

PUF: As you look at all the other projects that need to be developed, it does put more of an emphasis on the need to build new transmission.

Commissioner Lea Márquez Peterson: Right. We started with how fast Arizona is growing and we have data centers, semiconductor industries, chip manufacturers; so many that want to grow and build in Arizona. We can build as much generation as makes sense.

We have a lot of third-party developers coming to the state. Transmission is an opportunity to bring in wind from New Mexico or hydropower from the northwest and so on. But we need more transmission lines to do so.

The Western Electricity Coordinating Council, WECC, has produced a map that shows proposed transmission lines in the

near future and further out. I'm watching those to see where activity is occurring.

When you consider how many players are participating in the development of transmission lines, it is a complex issue. Then you layer on the community reaction and the environmental reaction. We're facing quite a challenge.

PUF: How should utility regulation respond or adjust to the needs and concerns in Arizona?

Whether explaining to elected officials or the public, we need to describe what encompasses flicking that light switch on the wall, all the components to ensuring energy reliability, and how Arizona is faring.

Commissioner Lea Márquez Peterson: It's communicating and educating the public. Why are we talking about transmission? What is that for? How does it serve Arizona?

Because we're right next to California and Arizonans are sensitive to being a pass-through state to reach the biggest market, California. That's not the case. We are growing rapidly too and need a lot of that energy load to come to our state.

It's educating and communicating with the public. It's working with local jurisdictions and our state legislators, so they know why this is occurring and what the need is. Those are important priorities.

PUF: A part of communication is that all these infrastructure needs have a cost. A piece of the puzzle is explaining why costs will rise.

Commissioner Lea Márquez Peterson: That's certainly a piece. Our priorities in Arizona are energy reliability and affordable utility rates. Most states are focused in that direction, as well as their various clean energy mandates.

Whether explaining to elected officials or the public, we need to describe what encompasses flicking that light switch on the wall, all the components to ensuring energy reliability, and how Arizona is faring.

We don't have natural gas production and have a couple of coal plants that are closing soon. We have lots of solar and battery coming to the state. We're improving natural gas peakers. We're doing as much as quickly as we can to ensure reliability.

We don't want to see rolling blackouts like our neighbor to the west in California. What else can be done? Part of that is transmission and what is that going to cost? Again, educating the public and local elected officials on what's happening.

PUF: Into the 2040s, how different do you think the electric power infrastructure will be?

Commissioner Lea Márquez Peterson: That's an interesting question. I'm attending an AI workshop at this conference. It seems like there're a lot of rapid changes.

Maybe we won't be as dependent on transmission by having small modular nuclear, if that occurs in ten or twenty years. I don't know the time frame; we're all determining what's affordable.

Because that would be in the community or onsite, that would change some of the infrastructure needed. It could look quite different.

PUF: As you think about infrastructure needs, how does it compete with concerns about affordability?

Commissioner Lea Márquez Peterson: It absolutely fits together, but again, it comes back to education. It's almost easier to explain aging infrastructure in the water industry, which we also regulate. We need to replace the wells and pumps and that's going to impact your utility bill.

On the energy side, it's so broad. There are the grid, substations, distribution and transmission lines, and generation. You've got these different pieces, but a homeowner is thinking, "What does this have to do with me? You're fueling Intel in the future."

No, this is interconnecting all our homes, businesses, and so on. Again, I think it's education and communication. ❍

Commissioner Tricia Pridemore

Georgia Public Service Commission, NARUC First VP

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure?

Commissioner Tricia Pridemore: The needs today are the needs they've always been – generation, transmission, distribution. We're seeing an increased need across our nation for new capacity.

We're seeing a technology industry that's exploding with new developments. The electricity industry needs to be there to support that. It's good for America. It's good for business. It's good for American citizens.

To do that, we've got to continue to build new generation. That includes gas, combustion turbines, and new nuclear. I also think that we're going to see renewables play a role. But long-term, for solar to be important to me as a regulator, it's got to be attached to long-duration energy storage.

PUF: What are the greatest concerns that you see as a regulator from Georgia?

Commissioner Tricia Pridemore: Lack of capacity and capacity shortfalls. That is remarkable to say, when I just finished regulatory proceedings on new, AP1000 nuclear units of five hundred megawatts each, that go to the vertically integrated investor-owned utility we have in Georgia.

So, for me to say capacity shortages, it's breathtaking. But we are learning every day that as artificial intelligence is being used across the corporate business spectrum, its processing needs are so much greater than anything we've seen.

I used to own a software company, and I had an ASP. We had a product that sat in the cloud that people could access in the early 2000s. The multiplication on the power need is so much greater now.

An AI search has ten more hits than a single, simple search engine hit. It's this increased need for processing, which means there's going to be an increased need for more capacity across the electric space.

For me to say capacity shortages, it's breathtaking. But we are learning every day that as artificial intelligence is being used across the corporate business spectrum, its processing needs are so much greater than anything we've seen.

PUF: How should utility regulation adjust to these needs and concerns?

Commissioner Tricia Pridemore: Utility regulators need to be nimble. We need to be open-minded. I think the best way to regulate is to be curious and want to understand the new business that's out there.

I also want us to be mindful that the way you may have done something at your Commission forever, isn't necessarily the way you've got to look at this issue or other outstanding issues.

We're going to continue to need to grow our nation's electric infrastructure. To do that, we've got to be nimble, curious, look into these matters, and make our decisions prudently.

Think about the long-term effects of these decisions. Think about ways that we can provide value for everybody in every rate class.

PUF: In the 2040s, what might the electric power structure look like?

Commissioner Tricia Pridemore: I'm fortunate to live in a state and be elected in a state where we do not have an RPS, so we are not constrained to lose the fact that we're still financial

Another big piece of affordability that's killing us right now, is everything going on at the EPA. Look at EPA 111, and how these measures could place fees and fines on different generation, which could price reliability out of reach.

regulators. We're still looking at the best-cost option for a safe, reliable, affordable system.

I'm also in a state that would never tolerate blackouts and curtailments. Because of that, we're able to look at an all-of-the-above solution, so that we can have diversity within our generation mix.

That diverse generation of nuclear, hydro, solar, gas. We still have some coal in Georgia, but that gives me so much flexibility, especially when I'm trying to be keen on reliability measures.

I also love the fact that I'm not in an RTO/ISO, and that we have a single, vertically integrated investor-owned utility that works with forty-one electric co-ops and forty-seven municipal providers, but everybody works together in a single system with single transmission capabilities.

PUF: How do infrastructure needs compete with concerns about affordability?

Commissioner Tricia Pridemore: Affordability is always top of mind, especially as we've seen inflation grow substantially, as it's grown over the last three-and-a-half years. The cost of everything has gone up, and the cost to create, produce, and maintain these systems has also gone up.

Affordability is key, but another big piece of affordability – besides those elements that come from Washington – that's killing us right now, is everything going on at the EPA. Look at EPA 111, and how these measures could place fees and fines on different generation, which could price reliability out of reach.

That's not right. Not when we're not getting a lot of benefit from it. We should be looking at the environmental benefits in light of reliability and ensuring access to clean, affordable energy in line with clean technology improvements. ❍

On May 15, which was in the middle of the week, a Wednesday, Dominion Energy and ComEd accounted for more than a quarter of the electricity demand across all the hours that day in PJM, 26.6 percent. Total PJM demand that day was 1,944,025 megawatt-hours, which was 17.2 percent of continental U.S. demand.

Commissioner Sarah Freeman

Indiana Utility Regulatory Commission

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure?

Commissioner Sarah Freeman: Recently, I read articles telling me that we need to keep coal online and build gas, that new nuclear is the best solution to our energy needs, and that renewables and storage can handle everything that's coming our way.

I'm glad Indiana is an all-of-the-above state when it comes to infrastructure needs because, otherwise, I might flounder when receiving all that type of information. Specifically looking at infrastructure needs, I identify transmission as a primary need. We need it to reduce our queues at the RTO level, decrease congestion, and spur renewable growth, particularly in optimal siting locations.

Supply chain issues, which aren't quite infrastructure, identify the need for a healthy supply chain, so we have the infrastructure needed for system resilience. I'm also looking at the need for grid-enhancing technologies, so we can lessen our reliance on large and costly physical infrastructure.

Also, I would be remiss if I didn't mention, I suppose, distributed energy resources and the needs they're going to bring going forward.

PUF: What are the greatest concerns for infrastructure needs?

Commissioner Sarah Freeman: Primarily cost, as well as challenges in siting and permitting different types of infrastructure across the country. I see the potential overbuilding of gas as a concern, as a bridge across the resource transition, which could possibly result in stranded assets and increased costs to my ratepayers.

Of course, if that overbuild happens, it's based on the intersection of well-intended policies dealing with environmental and reliability concerns. Timing is a concern of mine.

If that overbuild happens, it's based on the intersection of well-intended policies dealing with environmental and reliability concerns. Timing is a concern of mine.

We're seeing a resurgence of at least an interest in nuclear as a resource, but the extended timeline it takes to build those resources and get them online relative to the immediate need is concerning. Along with that, the ability to accommodate the projected immediate increases in load in the short term.

PUF: Should utility regulation adjust to address some of the infrastructure needs?

Commissioner Sarah Freeman: I don't think any adjustment in Indiana is needed at this point. I'm an economic regulator in a traditional ratemaking state with vertically integrated investor-owned utilities.

Our framework is solid. We're operating under tight timeframes already. I would not want to see any adjustments to the regulatory timelines because that would hamper our ability to do our job well.

I do see that there is a responsibility on the potentially adversarial parties before us to resolve as many issues as possible before they start a regulatory proceeding, to simplify what we are dealing with in these shortened time frames. It should yield better and more timely outcomes, as well as reducing the likelihood of an appeal after our decisions are rendered.

While I as a regulator am the ultimate decision maker on these issues, regulators aren't the only ones with the power, ability, and responsibility to determine outcomes.

PUF: Looking out to 2040, how different do you see electric power infrastructure looking?

Commissioner Sarah Freeman: I'll take a risk and say we're going to see more grid-hardening technologies due to man-made climate change and a greater number of extreme weather events between now and 2040. We'll see more automation of the technologies as AI technology advances.

Alluding to prior answers, we might see increased stranded assets if, in the shorter-term, storage and renewables or other technologies are able to supply needed capacity, alongside a projected gas build-out through the end of the 2020s.

We will probably see more load-side resources at both the residential and C&I customer classes. Also, some of the more residentially-based technologies; smart home and vehicle-to-grid could possibly be operating at scale by then, which would change the landscape. My staff asked me to also say fusion.

PUF: How do infrastructure needs compete with concerns about affordability?

Commissioner Sarah Freeman: I don't like to think of it as a competition, first of all. But if I need to think of it as a competition, I'll say they're both winners in that they occupy a large space in my mind all the time.

Ideally, we'll be looking at affordability and the infrastructure that is needed to maintain reliable service together, where one isn't taking precedence over the other, but they're both being evaluated simultaneously and comprehensively.

We're going to need wide-ranging types of support, perhaps looking at creative partnerships among utilities and other stakeholders for assignment of costs to the cost causers and beneficiaries of service, because sometimes those may not be the direct customers of a regulated utility.

We know infrastructure costs what it costs, and salaries and wages are paid at the level needed to maintain an experienced workforce for provision of these essential public services. But we are going to have to scrutinize more as to who bears the cost of providing the services.

We're going to need wide-ranging types of support, perhaps looking at more creative partnerships among utilities and other stakeholders for assignment of costs to the actual cost causers and beneficiaries of service, because sometimes those may not be the direct customers of a regulated utility. ❍

Commissioner Eric Skrmetta

Louisiana Public Service Commission

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure?

Commissioner Eric Skrmetta: Resilience is not only one of poles and wires, but it's one of continuity of baseload power resources. We need to focus on that to make sure we provide on all aspects.

We look at resilience and want to make sure we can withstand and bounce back on issues related to the infrastructure, but we need to have that same effect on providing power and keeping the power resources in play. Because if you put the poles and wires back up, you still have to put the electricity back on. We have to make sure we look at all elements of that equation.

PUF: Is there anything unique in that, that you see in Louisiana specifically?

Commissioner Eric Skrmetta: Louisiana is well positioned on natural gas for the resources, but we need to be looking forward. We've had testimony at our recent meetings telling us that we're going to need a lot more power. We're going to need as much as six thousand megawatts of power in the future.

I anticipate we're going to need at least three thousand in natural gas and as much as three thousand in new nuclear. The president of Entergy testified to that.

We have to play the long game and look to the future. We anticipate at least another one-thousand-megawatt facility coming online with natural gas quickly to produce electricity.

That is needed as we move forward with increases in demand coming from the chemical industry, which is somewhere in the one hundred fifty billion dollar range of investment that's going to be coming in along the Mississippi River.

PUF: As you look at the infrastructure in your state, what do you see as the greatest concerns?

Commissioner Eric Skrmetta: I hope we don't fail to maintain infrastructure; whether it's distribution, transmission, generation, and adequate reinvestment to keep up these resources. We have to balance the interests as those are important, but we also don't want to over-engage and overspend needlessly.

We must find the right amount. We want to make sure we're not pulling up resources that we have recently put in the ground. We don't want to have to pay for stranded assets.

We want to make sure we're doing right by the ratepayers. We certainly want the companies to be kept in healthy condition because there's no value to a utility that's teetering financially. It's finding that strike point to make sure we get it done properly.

PUF: How should utility regulation adjust to the needs and concerns, if it needs to adjust at all?

Commissioner Eric Skrmetta: In general, reasonable regulation maintains quality of the system, but federal regulation at the NRC could help us as we move forward in trying to add that component of nuclear power to our system. We already have two nuclear devices in Louisiana. We have another one that is part of our system in Mississippi.

But we have to find a way to adjust the regulatory process at the NRC to make it work more reasonably to where we can clear a path to move new nuclear technology into the systems. That is so nuclear can benefit stability and baseload power additions and do so as these systems put us in a net-zero position, with a combination of natural gas, as we move into the future.

We have to adjust the regulatory process at the NRC to make it work more reasonably to clear a path to move new nuclear technology into the systems.

PUF: Look to 2040. How different do you think the electric power infrastructure will be in another twenty years?

Commissioner Eric Skrmetta: From what we're hearing now, particularly on artificial intelligence and data centers and the unknown beyond that, it's going to be a vastly larger amount than we have now. The projections are showing that utilities are going to have significant increases.

We need a five-year lead time at a minimum, even if we just look at natural gas resources to be added and probably need seven or eight years for nuclear. But we have to play that lead game to get us to that point of reacting to the future. I hate to say this, but we have to work the crystal ball and with all relevant factors to get us to 2040.

We're going to have to recognize that no one is saying there's going to be a reduced demand for electricity. It's a super-addictive commodity.

We know that with the technologies that are going to be craving it, that we're going to have to build more resources and

get them done in a way that can get us to that net-zero goal established by the federal government. To do that, we're going to have to find our way to balance that power resource between natural gas and nuclear for the future.

PUF: As you think about infrastructure needs, how does it compete with concerns about affordability?

Commissioner Eric Skrmetta: This is where reasonable regulatory can help, as concerns for the public cost have to be closely balanced with keeping the lights on. We have to make sure that deliverability of electricity is there, but at the same time, we have to balance out these interests on cost.

It goes back to the old expression of, the first thing you have to do is make sure when people hit the switch that the power comes on. At the same time, when they get their bill at the end of the month, it's the lowest bill we can effectively create for them.

There're a lot of people in between those two points who are trying to affect the price of electricity, and not always in a good way. We must find a way to balance these interests. That

I hope we don't fail to maintain infrastructure; whether it's distribution, transmission, generation, and adequate reinvestment to keep up these resources. We have to balance the interests as those are important, but we don't want to over-engage and overspend needlessly.

is a critical description of what Public Service Commissioners should do, which is balance interests.

But we should find a way to always work toward improving the quality-of-service cost in life for the ratepayers and establish a balance that allows for companies to maintain a healthy existence so they can continue to deliver quality products at the right price to the consumer. ❍

Chair Pat O'Connell

New Mexico Public Regulation Commission

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure in New Mexico?

Chair Pat O'Connell: In the short term, it's getting through the supply chain challenge that came out of the pandemic and the Auxin Commerce Department Complaint. We shut down a coal plant and don't have the replacement resources online yet because of those issues.

We're in this moment when items like transformers are hard to get. That can slow down the change, including the need to address resource adequacy. It also slows down economic development because new loads need transformers too. That's the immediate need, it's equipment.

The longer term is getting to a vision of where New Mexico can sit within the western grid. We've historically supplied electricity to the west through coal, and now are poised to supply electricity to the west through wind.

That requires different systems and getting those built. If everybody's aligned on what we're doing, we can optimize, and get it done affordably and reliably.

PUF: What most concerns you regarding infrastructure?

Chair Pat O'Connell: What we're trying to address is resource adequacy. That ends up being an infrastructure issue because load must be served.

We're building a system with resources that utilities don't

Regulation is changing in real time in response to those laws. I don't think of that as forward-looking. It's what I'm doing right now.

have comfort operating yet. So, they're being conservative in assumptions of what they can do.

We might find challenges that we don't imagine yet as we're working through that system. Getting experience with the new stuff, I think, both on the regulatory and utility sides, is important.

PUF: How should utility regulation adjust as you look at some of these infrastructure concerns, if at all?

Chair Pat O'Connell: I've been thinking hard about does regulation need to adjust? It's issues like liquidated damages in power purchase agreements.

If you're trying to minimize what goes on somebody's bill and a utility is negotiating a power supply agreement, what gets thrown out is liquidated damages if things don't come online on time or don't perform right out of the box because the customer pays for that insurance.

The pandemic showed us we could have used some of that

insurance. So, is it worth it for regulators to think the least-cost solution may not be the best device for providing service? That's an area where I'm thinking regulation needs to change.

The bigger thing is, especially in New Mexico, we've got state policy. It's about getting it implemented. So, we're working through a slate of new laws and working through it with the utilities.

Regulation is changing in real time in response to those laws. I don't think of that as forward-looking. It's what I'm doing right now.

PUF: Look into the 2040s, what do you see as being different for electric power infrastructure?

Chair Pat O'Connell: Out west, we will have more organized regional markets. Right now, there are deep conversations going on about how best to make that happen, how to ensure the best customer benefits, and concerns about cost allocation.

Those are the kinds of things we're talking about now.

I think down the road we will have answered enough of those questions that a regional market will exist. That can be transformational for a place like New Mexico, where our ability to supply clean energy to the grid versus our demand, can make us a huge supplier.

We will benefit from exporting electricity reliably. That's what I'm looking forward to in forty years, is taking advantage of what we have to benefit New Mexico.

Items like transformers are hard to get. That can slow down the change, including the need to address resource adequacy. It also slows down economic development because new loads need transformers too. That's the immediate need, it's equipment.

PUF: There will be more costs that need to be recovered to build infrastructure. How will that impact affordability?

Chair Pat O'Connell: Affordability is crucial. We are regulating these services because they are so important to daily life, to running a business. But using the word affordability without digging into what it is, is something that I spend a lot of time thinking about.

If you're talking about electric rate affordability, if you're building new infrastructure, you're probably adding cost. But if you're building new infrastructure to increase sales, your rates might not be changing that much.

Then affordability becomes making sure customers have opportunities to manage their bills. They should have the information to be sophisticated users of electricity, or there should be aggregators who are providing that, while truly looking out for their best interest.

Frequently you'll hear that we have to build new infrastructure, and that makes it not affordable. I don't accept that.

I think that building new infrastructure puts pressure on costs, but it doesn't automatically mean unaffordable. That's the challenge for regulators, is to put these issues together so we're continuing to provide the public benefit of electricity used to power our daily lives, and in a way that's safe, reliable, affordable. Just because things are changing doesn't mean it's not affordable. ❍

Commissioner Floyd McKissick
North Carolina Utilities Commission

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure?

Commissioner Floyd McKissick: When I think about where we are today, it's all the new load growth that is projected as a result of data centers, advanced cloud computing, blockchain operations, and crypto mining. I realize that we will need to not just review resource adequacy but will need to contemporaneously invest in the infrastructure that's required to meet ever growing demand, while meeting decarbonization targets set by many states that will inevitably impact electric generation options.

In North Carolina, I think about the potential for increased reserve margins for utilities due to extreme weather, the impact of economic development decisions, as well as potential load growth from the electrification of the motor vehicle fleet. With all that demand coming onto the grid in the near and long term, it gives me concerns, as well.

The power grid is going to be challenged. There was a period where there was anemic growth and now the growth is substantial.

I was reviewing an article on the FERC report issued in December of 2023, which was projecting that nationwide demand would grow 4.7 percent over the next five years, whereas in 2022 demand was only projected at 2.6 percent. There's a lot to contemplate, a lot to deal with, as well as transmission capacity that will also need to be provided.

PUF: What are your greatest concerns about infrastructure?

Commissioner Floyd McKissick: We must have the grid ready and able to respond to that increased demand. We need to have transmission capacity in place.

Often today, there's a great emphasis on renewables, but where those renewables are located, there's not always the transmission capacity to get the power generated to where the power is needed. That's among the things that give me great concern. We've faced that in North Carolina, and I know that's occurring across the country.

I think about the potential for increased reserve margins for utilities due to extreme weather, the impact of economic development decisions, as well as potential load growth from electrification of the motor vehicle fleet. With all that demand coming onto the grid in the near and long term, it gives me concerns. The grid is going to be challenged.

A group called Americans for a Clean Energy Grid looked at the ten regions across the country and gave them an alphabet grade, theoretically between A to F, but there were only two regions that got a B based upon their regional transmission planning. Those were MISO and CAISO.

The rest of the country received grades of C, D, and F. Transmission capacity, and particularly the regional emphasis, needs to be in place.

PUF: Does regulation need to adjust to address infrastructure needs and concerns?

Commissioner Floyd McKissick: I think so, however the challenge is that each state must create the right pathway that's most effective and which works in their jurisdictions.

For example, in North Carolina we have legislatively mandated decarbonization goals we must comply with and we're closing out eighty-four megawatts of coal generating facilities. That's a target. We've got dates set to accomplish that.

But at the same time, we need to bring in renewables and we're considering technologies such as SMRs, as well as onshore and offshore wind. However, we don't know when certain new

On May 15, which was in the middle of the week, a Wednesday, generation of electricity totaled 11,300,442 megawatt-hours in the continental U.S across the 24 hours of the day. Continental U.S. is all the states excluding Alaska and Hawaii but including the District of Columbia. Of that May 15, 2024 total, 39.2% was natural gas-fired generation, 19.1% was nuclear generation, 14.3% was coal-fired generation, 11.9% was wind generation, 8.3% was hydro generation, and 5.7% was solar generation.

In contrast, five years prior, on May 15, 2019, also a Wednesday, generation of electricity totaled 10,457,255 megawatt-hours in the continental U.S. So, from May 15 of 2019 to May 15 of 2024, generation increased by 8.1%.

Of that May 15, 2019 total, 33.9% was natural gas-fired generation, 22.6% was nuclear generation, 22.4% was coal-fired generation, 6.0% was wind generation, 11.0% was hydro generation, and 1.8% was solar generation. Much more coal-fired generation than on that day five years hence.

technologies will be available, and how we can make certain we have a reliable power supply and grid to accommodate increasingly growing needs and demands.

PUF: In the 2040s, how different will electric power infrastructure look?

Commissioner Floyd McKissick: The term infrastructure is broad, and it encompasses a lot. When I think about what will be different in 2040, I think about what new technologies are likely to have been brought to market by that time. I think SMRs will be a part of the electric generation fleet.

I think about the possibility that hydrogen is going to be available. Is it at a point yet in time where it will be commercially viable and feasible? I don't know. I think about all the charging stations that are going to be out there in 2040, when a large segment of the motor vehicle fleet will be using electricity as its fuel.

When I think that far out, it's going to be radically transformed. We'll be reaching many of those carbon-reduction targets, which are now just goals or targets. We won't perhaps be at net-zero yet across the country, but hopefully some states will be approaching that.

It'll be a new paradigm with all the increased demand coming. Who knows what's going to happen with cloud computing by then and with AI, with additional demand that's going to be on the grid.

Hopefully, we'll have overcome many of the transmission challenges that are looming. So, it'll be a transformation in progress that will present us with new challenges, and opportunities.

PUF: How do infrastructure needs compete with concerns about affordability?

Commissioner Floyd McKissick: There are serious concerns about affordability. This will not be a cheap transition, moving to carbon neutrality and building the infrastructure needs that are necessary. There are many challenges.

It's about helping segments of the population, so they're not struggling because of the cost and pathway of having a power grid that's essential, necessary, reliable, and allows us to modernize in a way that's critical as we decarbonize, if we're going to be successful.

It's up to Commissioners within their jurisdictions to figure out how they can decrease the burden on those who are most financially vulnerable. Do they create programs that might provide a certain bill credit to those customers qualified for LIHEAP or CIP? Do they define affordability in terms of what a person pays for utilities as a percentage of their income?

These are variables each state will wrestle with and what works in one jurisdiction may not work in another. We will be challenged to think outside the box.

Do they look at what would be referred to as an energy burden based upon the amount of income that people have? It's all about helping segments of the population, so they're not struggling because of the cost and pathway of having a power grid that's essential, necessary, reliable, and allows us to modernize in a way that's critical as we decarbonize, if we're going to be successful.

All of that is going to come at a cost and we must come up with a way of mitigating that impact on those who are most financially vulnerable. ❍

Chair Steve DeFrank

Pennsylvania Public Utility Commission

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure?

Chair Steve DeFrank: They are twofold. First, are ever increasing cyber and physical security threats. We discussed that in our panel in Santa Fe; AI and how that's entering into this space, particularly utilizing AI for cyber threats.

When we talk about cyber threats, I always talk about how we have to be perfect. They throw everything against a wall, and if something gets through and gets in, it could create havoc. Near perfect isn't good enough; we have to be perfect.

Then it's increasing physical security threats to substations. I visited the Riazzi substation in the Duquesne Light territory earlier this year, and it's a state-of-the-art facility, with twenty-foot fencing around it.

You can't see inside it, as it has bulletproofed fencing. Unfortunately, folks like to use these facilities as target practice just for fun, other times there're more nefarious motives, either of which create havoc.

Those threats are some of the important issues we're seeing with power infrastructure. The other is resiliency and reliability.

It's what we always talk about when we discuss this subject, and we're seeing more adverse weather becoming the norm. We had a meeting with one of our electric distribution companies earlier this week and for reportable storms each year we're seeing an increase.

We're already in April and far surpassed April of 2023 in terms of reportable storms for this electric distribution company. It looks like '24 will top '23, which set a record, and '23 topped '22, which set a record. That seems to be the norm.

It's how we address that, first to minimize outages and then what we do to restore customers quickly and efficiently when those storms occur. Then from the reliability standpoint, it's our ever-increasing load and how we handle those peaks and changing shifts of those peaks.

And finally, more folks are working from home. Our traditional twenty-four-hour load curve of twenty years ago is not the load curve today, and that's simply because we've changed our habits. How our systems adjust, so we meet reliability concerns in an affordable and cost-effective manner, that's the key – striking that balance.

PUF: As you look at infrastructure, what are the concerns about trying to address some of those needs?

Chair Steve DeFrank: Effectively managing distribution planning with load growth and distributed generation to avoid stranded costs. Twenty years ago, the annual load growth of any electric distribution company was approximately one to two percent. Today, we have projections for some utilities up to and even over five percent, with the norm being in the two to five percent range.

We recently instituted in Pennsylvania our battery storage proceeding policy statement. The policy makes it clear utilities may utilize battery storage as a distribution tool, as a non-wires and poles alternative to foster reliability.

While this is a huge challenge, it also creates an opportunity for utilities to leverage more demand to invest in the incremental upgrades needed to meet this new volume. However, if utilities mismanage investments to support growth that does not appear, this overbuild will lead to stranded costs for consumers.

Getting an accurate prediction. That's a challenge with data center proliferation and the amount of power they use. That's not going to end anytime soon. The question is where they're going and how that location will impact the grid.

Adding to this challenge are the dynamics brought about by distributed generation. Most behind-the-meter generation is solar that does not have a 24/7 profile. The result of the intermittent profile could be a grid with greater peaks, resulting in an expensive and uneconomic grid for consumers.

PUF: Does utility regulation need to adjust to address some of these concerns?

Chair Steve DeFrank: Absolutely. We recently instituted in Pennsylvania our battery storage proceeding policy statement. The policy makes it clear utilities may utilize battery storage as a distribution tool, as a non-wires and poles alternative to foster reliability.

Allowing electric distribution companies to utilize batteries, if it's cost-effective, makes a lot of sense. The more tools we can put in a utilities' toolbox, the better off we're going to be.

There will be more microgrids, for instance. With the increase in number and severity of weather events, the need for microgrids is becoming more apparent.

Pennsylvania is in phase four of our energy efficiency and

conservation plans. We're going to be entering phase five in June of 2025.

All of these are going to come into play. We're not going to find one silver bullet to address all these concerns. It's going to be all available tools coming together to address new reliability issues.

Distributed energy resources, we're seeing more behind-the-meter applications, whether community solar or roof top. More folks are putting on solar panels, which creates a need to ensure the local distribution grid can handle increased distributed generation.

Distribution rates. Pennsylvania passed legislation allowing for alternative ratemaking, which allows utilities the option to utilize time-of-use, incentive, multi-year, decoupled, and other distribution rate designs. We haven't had significant applications of these designs yet, but the tools are in the toolbox if utilities want to file a rate case that veers away from volumetric ratemaking.

We're always open to new ideas, to think outside the box because of the challenges we're facing. We can't think in traditional ways on these issues like we did twenty years ago because they're too broad and diverse.

Pennsylvania passed legislation allowing for alternative ratemaking, which allows utilities the option to utilize time-of-use, incentive, multi-year, decoupled, and other distribution rate designs. We haven't had significant applications of these designs yet, but the tools are in the toolbox.

PUF: How different will electric power infrastructure look in 2040?

Chair Steve DeFrank: Earlier this year I was touring one of our electric distribution companies in the state and it has a fully implemented smart grid. We're going to see more of that.

It's a SCADA program where if there's an issue on the grid, it is isolated, power is moved around, sectionalized, and impact is minimized. The system I looked at did all of that within a two-to-three-minute time frame. It isolated an outage, which minimizes impact to the customer.

You're going to see more of those types of systems, and distributed generation is going to continue to increase. However, we will still have our traditional backbone grid to continue to be the "freeway" system for electricity to be delivered to our homes and businesses.

There will be more distributed resources on it, but even forty years from now, we're going to have a distribution system that will be even more important in facilitating all these various technologies. But even with all of that, I think we'll still be able recognize it from what we see today.

Additionally, there will be more microgrids spread throughout and more ability to section off parts of that grid. It's going to be more versatile in meeting challenges I described earlier.

Hopefully, there will be more battery deployment and other non-wire alternatives in place. But we'll certainly recognize the grid.

PUF: How do infrastructure needs compete with concerns about affordability?

Chair Steve DeFrank: We always ask that question, and we ask it as though it's either one or the other. I think we can have both. It's striking a balance.

How do you get there? I believe the cheapest power and most affordable power is the power we don't use. Efficiency programs help us keep that reliable grid affordable.

We have a robust program, and most states are doing at least something with energy efficiency. It's an important tool particularly in the PJM footprint, with resource adequacy concerns. Part of that answer, as well, is efficiency. ❍

Chair Jehmal Hudson

Virginia State Corporation Commission

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure?

Chair Jehmal Hudson: The power grid has been the most important electric system for well over a hundred years, but that system is getting older every day. With age comes increased safety and reliability risks. Failures in these areas negatively impact both people's everyday lives and the broader economy.

The most important concern for me is how we can address these present risks, as well as tackle the electrification requirements of the future. For example, economic growth, transportation electrification, and the proliferation of AI all will demand more and more from our aging infrastructure.

PUF: Let's talk more about your greatest concerns for that infrastructure.

Chair Jehmal Hudson: Sure. The grid today challenges us in a myriad of ways. There are thousands of miles of physically old poles and conductor that are reaching, or have surpassed, the end of their useful lives.

And instead of in-kind replacement, we must strategically consider how to improve infrastructure. For example, using steel poles instead of wood. Or replacing outdated meters at people's homes with more advanced meters that support options like time-of-use rates.

There is pressure not just to replace parts, but to modernize the grid, and to do so with energy from carbon-neutral resources.

The most important concern is how we can address present risks, as well as tackle electrification requirements of the future.

Then of course, there're interconnection queue challenges we're all familiar with. But when we talk about the greatest concern, it's about costs. How can we as a society, and as regulators particularly, support utility plans and projects that accomplish all this, at costs that are just and reasonable for ratepayers to bear?

PUF: As a regulator, how should utility regulation adjust to these needs and concerns, if at all?

Chair Jehmal Hudson: In Virginia, the State Corporation Commission implements the policies of our General Assembly, and we try to do that faithfully.

Where we have discretion, it's important that we try to balance the consumers' and utilities' needs. We look at evidence like whether a cost-benefit analysis supports a utility's request, or whether less expensive options have been considered.

That aspect of utility regulation hasn't changed. What has changed, to some extent, are the types of cases we're seeing. For example, ten years ago, our utilities weren't filing proposals to modernize the distribution grid. Our Commission also has seen

On May 15, which was in the middle of the week, a Wednesday, generation of electricity totaled 265,667 megawatt-hours in ISO New England across the 24 hours of the day. Of that total, 52.5% was natural gas-fired generation, 31.5% was nuclear generation, 9.5% was hydro generation. Only 2.4% was solar and wind generation combined. On that same day, generation of electricity totaled 1,719,094 megawatt-hours in MISO. Of that total, 43.0% was natural gas-fired generation, 25.1% was coal-fired generation, 13.7% was nuclear generation, 12.5% was wind generation, 2.9% was solar generation, and 2.3% was hydro generation.

On that same day, generation of electricity totaled 351,392 megawatt-hours in New York ISO. Of that total, 51.8% was natural gas-fired generation, 23.4% was nuclear generation, 22.0% was hydro generation. Only 1.0% was solar and wind generation combined; all from wind generation. On that same day, generation of electricity totaled 748,496 megawatt-hours in SWPP. Of that total, 39.8% was from wind generation, 28.1% was natural gas-fired generation, 21.6% was coal-fired generation, 6.8% was nuclear generation, 2.7% was hydro generation, and 0.9% was solar generation.

an uptick in requests for transmission line builds and rebuilds to support the population and our economy, including data centers.

I don't think our utility regulation process has changed or needs to change. We continue to look at the priorities set by our legislators and consider what's in the public interest. But we are doing that analysis in a broader array of cases.

PUF: How different will electric power infrastructure be in the year 2040?

Chair Jehmal Hudson: I certainly envision an electric grid that supports transportation electrification. To make that a reality, we have to look at charging infrastructure. We also have to consider rate design, such as time-of-use options or other mechanisms.

We have to consider storage. Could renewable energy captured during the day be used to charge vehicles at night? Could fully charged vehicle batteries return energy to the power grid when it's stressed? There's a lot to consider.

Most important, we have to look at consumer adoption and affordability. But I do think electrification of transportation will be a game changer in 2040.

PUF: As you think about infrastructure needs, how does it compete with concerns about affordability?

Chair Jehmal Hudson: I see them both as equally competing interests for state regulators. Our society expects the grid to do more, without interruption, than when the power grid was built out eighty to one hundred years ago.

I don't think our utility regulation process has changed or needs to change. We continue to look at priorities set by our legislators and consider what's in the public interest. But we are doing that analysis in a broader array of cases.

And without dependable infrastructure, reliability suffers, with cascading effects on people, businesses, and the broader economy. Competing with these expectations and concerns is the reality of what ratepayers can afford.

Ratepayers fall across the financial spectrum, and some people already have to choose between paying their electric bill or buying other necessities like medication. How much of a rate increase should ratepayers be expected to pay, for the benefits they'll receive from enhanced infrastructure? As state regulators, we are always trying to balance those multiple interests.

PUF: Does affordability outweigh the utility's financial requirements?

Chair Jehmal Hudson: In my role, I don't see that one outweighs the other. We Commissioners take each case as it comes and decide issues based on the record before us.

We might, for example, look at whether we can approve part of an infrastructure proposal, instead of a utility's full request, out of concerns for affordability. It's a juggling act to keep the lights on at prices ratepayers can afford. We strive to make choices that strike the right balance for all concerned. ❍

Commissioner Ann Rendahl

Washington Utilities and Transportation Commission

NARUC Second VP

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure?

Commissioner Ann Rendahl: In addition to the transmission needed to bring on the utility-scale renewables, clean energy, and capacity that is being built outside of the load centers, and the amount of energy and capacity needed to meet the growing demand, we need to focus on the distribution system. Some utilities have started focusing on creating a smart distribution grid infrastructure.

The distribution system needs communication and management systems to provide a greater understanding of what's happening on the distribution grid as large and small customers are installing more distributed energy resources. With this understanding of what's happening on the distribution system, utilities can better manage peak demands and ensure reliability.

In addition, for both the distribution and transmission systems, the most important needs are focusing on system resilience and mitigating extreme weather issues; both hot and cold weather, wildfire protection, wind, and protecting generation equipment, transformers, distribution and transmission lines, to ensure reliable electricity for customers. Those are the big issues that I see.

PUF: What are the greatest concerns within this infrastructure? The pieces that if you don't deal with now, you're going to regret.

Commissioner Ann Rendahl: It's beefing up how resilient the infrastructure is to extreme weather. Replacing or upgrading the problem areas of your system susceptible to wind, tree strikes, to ensure consistent operation in heat or cold, and addressing the problem areas of your system that could spark a wildfire or be seen as sparking a wildfire.

That's a huge financial risk for utilities, as well as a safety risk for their employees and customers. Utilities also increasingly need to protect their systems from physical attacks, which we've seen, and cyberattacks, the threat of which just doesn't stop.

PUF: Do there need to be changes? Do you have what you need in terms of being able to deal with some of the infrastructure needs you see coming?

Commissioner Ann Rendahl: From the regulator's perspective, there is always the argument that utilities do not get recovery for costs fast enough, that regulatory lag creates a barrier to meeting their infrastructure needs. We've done a few things in Washington State to address that issue, including allowing for recovery of investments in rates up to four years beyond the rate effective period.

The risk of wildfires to the grid impacts a utility's ability to attract capital to improve its system, and insurance becomes either unaffordable or not available. These costs create additional affordability issues for customers.

The rate recovery process will never be perfect because utilities always must come to the Commission and get approval for recovery of expenses – there will always be some lag. But allowing recovery in rates on a provisional basis, then reviewing the rates to ensure the utility put in service projects it said it would build, is a process our legislature adopted, and we are in the process of implementing.

The process includes an annual review, with a refund option if the utility was not able to put the plant in service, as the utility should not be recovering costs for or a return on assets that are not in use.

There's such a need for additional capacity that we're looking at addressing how utilities can get a return on a purchase power agreement to make it worth their while to get the capacity they need. It's going to be a continuing conversation about how to make the regulatory process as efficient as possible and as close to the need for recovery as possible.

The Washington Commission has also approved trackers for wildfire prevention and mitigation costs, which helps with recovery of costs for these important efforts. I don't think there's a single magic solution. It's going to be a suite of things that we continue to improve on over time.

PUF: Looking out twenty years into the 2040s, how different do you think the electric power infrastructure will look as we move forward with decarbonization?

Commissioner Ann Rendahl: There will be more nuclear power on the system. There'll be more battery systems on the grid, both on the distribution and the bulk power levels. The distribution grid, with increased distributed renewables and storage, will provide more demand flexibility to the system.

There'll be things we haven't heard of yet. Hydrogen will likely be an important resource for reducing emissions in industrial systems, but not so much for serving residential and distribution system customers.

As the grid is decarbonized, there will be solutions for different parts of the industry sectors that work best for them to continue to be competitive in their businesses. There's no one size fits all here. We have to continue looking at the most efficient ways of serving customers, the most affordable ways of serving customers, and still reaching our goals.

We don't know everything we're going to need, but we should try to plan for things as we start learning about them. I appreciate all the work the Department of Energy is doing, and all their commercial lift-off reports to provide the information, details, and plans for these potential options that do need to get to commercial viability.

But at the same time, utilities should be planning for various options, some of which in the long term may come to fruition and some may not, but still include what is the best, least-cost effort for customers.

PUF: How do infrastructure needs compete with concerns about affordability?

Commissioner Ann Rendahl: It's not a competition, but we will need to continue balancing infrastructure needs and affordability as we go forward. Customer affordability is one of the biggest issues we face, not just addressing the needs of those customers who have difficulty affording this essential service but ensuring that the solutions for affordability do not create financial pressures for other customers.

In a perfect world, there is a lot we need to do to reach the goals that states like Washington have or even to meet the growth needs of states without clean energy goals. There is so much that we need to do to protect the electric grid from cybersecurity, to protect against wildfires, and to meet the growing demand with whatever capacity we're putting in.

We are also seeing that the risk of wildfires to the grid impacts a utility's ability to attract capital to improve its system, and insurance becomes either unaffordable or not available. These costs create additional affordability issues for customers.

These important expenses are going to continue to increase, yet there is a large segment of the population that is not seeing the economic growth, and will continue to have issues with affordability, with being able to pay.

We're going to have to continue to figure out how best to manage that, to prioritize expenses, because if a utility's customers can't pay their bills, then the utility won't have the necessary funds to operate, unless the utility is getting funds elsewhere to serve its customers. ❍

The distribution system needs communication and management systems to provide a greater understanding of what's happening on the distribution grid as large and small customers are installing more distributed energy resources. With this, utilities can better manage peak demands and ensure reliability.

Chair Mary Throne
Wyoming Public Service Commission

Much infrastructure growth and research and development are going to require continued government intervention, whether in the form of funding for research or loan guarantees. The picture, in my mind, has been getting a little clearer over the last few years, but I still don't see a clear path to either 2030 or 2040.

PUF's Paul Kjellander: What are the most important needs for electric power infrastructure?

Chair Mary Throne: The greatest challenge is that we have to find some way to ensure that we right-size everything, that we don't build too little and that we don't build too much, and that we build the right mix, so we have resiliency, reliability, and adequate resources. I continue not to feel confident that we've put it all together yet.

PUF: What are the greatest concerns about infrastructure needs?

Chair Mary Throne: Looking at the western region, with which I'm more familiar, we have growing disruptive or extreme weather events. I almost don't like to call them extreme anymore because they're somewhat recurring. Those put strains on the system.

In addition, it seems that everybody is facing increased demand with a lot of potential data centers. Ordinarily that would be a good thing and is a good thing for most economies.

Our communities certainly want those but getting everything built and then on top of that, you have the overlay of some states' and businesses' clean energy goals, and it's just a difficult situation.

PUF: How should utility regulation adjust to needs and concerns for infrastructure development?

Chair Mary Throne: The right tools need to be in place for the current circumstances and that's true whatever you're regulating. Relying exclusively on the models we've used in the past, when you built one massive coal-fired power plant, then built the transmission to the load, is not the answer anymore. Having the right tools to assess all these different pieces is important.

PUF: How different might the electric power infrastructure look in 2040?

Chair Mary Throne: It's already starting to change. I wish I had a better idea of what it needs to look like in 2040 to meet all these competing demands, but I think it's going to be a more substantial percentage of renewables and distributed resources.

The need for flexible, dispatchable baseload, however you want to title it, could be met by a mixture of sources. We continue to expect in Wyoming to have a decent-sized carbon-capture project, advanced nuclear, and at some point, hydrogen.

(Cont. on page 49)

Power Walk

About This Painting

BY PAUL KJELLANDER, PUF SENIOR ADVISOR, FORMER NARUC PRESIDENT

Transmission lines and towers are not the subject of poetry and songs. Instead, this infrastructure when proposed becomes the topic of troublesome rhetoric that focuses on the eyesore it is said would mar the landscape.

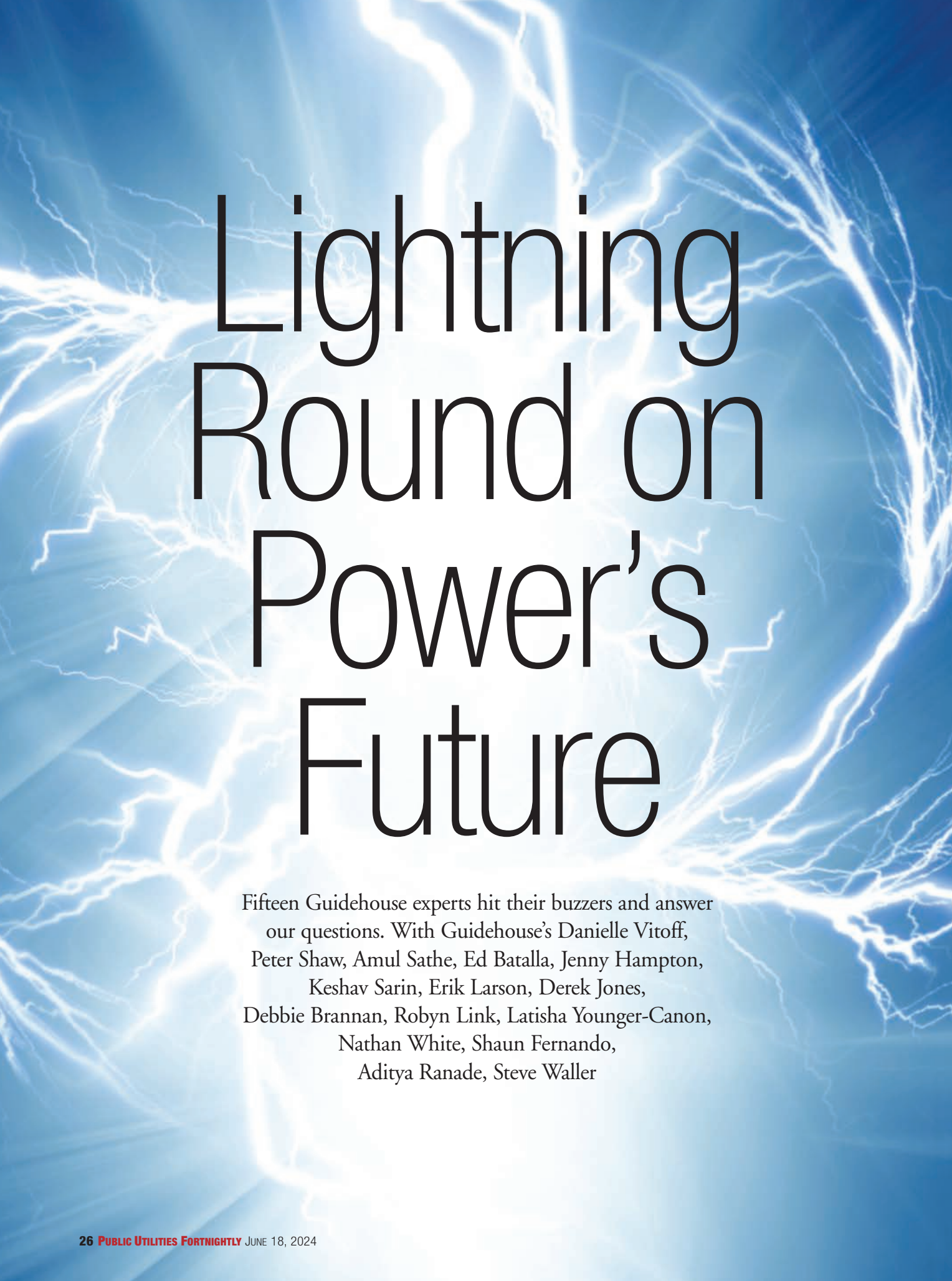
I have never felt disdain for poles and wires. To the contrary, without them, little flourishes. Without energy, and the means to move it to communities, businesses, and homes, our way of life would be less bright.

A few years back, during a public hearing about a proposed transmission line, one witness after another took the stand to complain about how a project would ruin the character of their town. I listened, and avoided the temptation to challenge the belief that this development would somehow destroy their viewshed.

My perception of transmission towers is largely shaped by the view from my backyard. On the other side of our fence, large metal towers rise to support high-capacity wires that carry energy to the west of my neighborhood. I have lived among them for so long that their presence is barely noticeable.

So, when people complain and say, "not in my backyard," I find it difficult to commiserate. When I see transmission towers, I see the infrastructure necessary to drive economic opportunity and prosperity.
And the energy that makes everyday life easier to enjoy.

The title of this painting is "Power Walk." It depicts a young couple, my son Justus and Courtney, as they enjoy a stroll along a path just a few blocks from my back door. These transmission towers that line the walkway are clearly visible. But they are indeed an essential part of the landscape. PUF



Lightning Round on Power's Future

Fifteen Guidehouse experts hit their buzzers and answer our questions. With Guidehouse's Danielle Vitoff, Peter Shaw, Amul Sathe, Ed Batalla, Jenny Hampton, Keshav Sarin, Erik Larson, Derek Jones, Debbie Brannan, Robyn Link, Latisha Younger-Canon, Nathan White, Shaun Fernando, Aditya Ranade, Steve Waller

How can commercial & industrial users reduce their impact on the grid during their electrification process? How are you seeing utilities manage this increase in demand across the board?

Danielle Vitoff: Large C&I users are experiencing increased pressure to decarbonize their operations from customers, environmental stakeholders, and investors while having access to more financial incentives geared toward accelerated deployment of clean energy. The impact of these trends is pointing to a tipping point for industrial decarbonization and a substantial growing demand for clean electricity. If managed incorrectly, this demand growth could have detrimental effects on all electricity system users.

As large C&I users consider their decarbonization strategies, they should work with their energy providers to consider their sites' unique needs and opportunities. The specifics of each user's connection point to the grid and loads served may result in very different solution portfolios being viable options. In most cases, industrial users and energy providers working together to develop decarbonized solutions can provide increased value. Examples include:

Developing clean power microgrids to support electricity-intensive industrial areas, particularly where extended delays for grid connection could limit capacity and access to clean electricity.

Locating renewables or behind-the-meter (BTM) storage on industrial sites could provide quicker access to renewable energy and limit any greenfield disturbance that is often encountered in siting renewables.

Optimizing industrial process requirements among electric, gas, and hydrogen by considering the dynamics of delivering each energy carrier to the site.

Considering the impact of participating in demand response programs and aligning industrial production to help mitigate usage during peak periods – which will be hardest to meet with renewable power.

Bottom line: Utilities must be more closely connected to their industrial customers and understand their decarbonization goals, pathways, and timelines. The decarbonization of industrial demand has potential to change the loads that utilities must be prepared to serve. ❍

Utilities must be more closely connected to their industrial customers and understand their decarbonization goals, pathways, and timelines.

– Danielle Vitoff

How are regulators having an impact on utilities' needs to invest in resilience; are they assigning appropriate value to averted outages relative to their mandate to keep ratepayer costs low?

Peter Shaw: Over the last ten years, the clean energy transition has transformed the power industry, focusing squarely on mitigating carbon emissions from electricity generation and ushering in a seismic shift to intermittent, renewable power generation spurred by federal and state policy mandates and administered by state regulatory commissions.

Government and utility industry leaders are increasingly acknowledging the escalating risks to power grids from extreme weather hazards and other risk vectors. While investments in utility carbon mitigation help stave off the worst effects

of global climate disruption, resilience investments reflect how climate adaptation is the B-side of the energy transition – and will be crucial and costly.

The need for system resilience is more acute where electricity demand is growing exponentially due to forces like electrification, population, and economic growth; an expanding need for data centers; and rising interest in green hydrogen as a decarbonization strategy.

For example, growing population centers in the Southeast and Southwest are susceptible to high wind events, extreme heat, drought, flooding, and storm surges. Hardening infrastructure and enabling faster outage restoration from weather hazards are imperative when load growth is driving system expansion, and our economy and security is increasingly reliant on a stable and continuous power supply.

A Guidehouse review of utility resilience plans and associated regulatory proceedings shows how both utilities and regulators are negotiating this emerging terrain cautiously. In most cases, utilities must propose a rubric for establishing the value of resilience investments, using rigorous modeling.

Investments, policies, and standards vary across regulatory jurisdictions governing how utilities file their investment plans, demonstrate need and prudency, recover costs, and earn on those investments. The trend is toward using sophisticated weather hazard models to project probabilistic risk that different weather hazard types will occur, on what assets they will likely have an impact, and their frequency and intensity. Weather hazards can be highly localized, so predictive models must assess outage risks differently for different geographies and areas of the system, for example, at the electric circuit level.

Utility regulators must assess utility investments, including those contained in various forms of utility resilience plans. Regulators now require that utilities define and report resilience metrics to demonstrate the need for grid investments and measure their effectiveness. Benefit-cost analysis quantifies evidence that an investment's benefits can justify its costs.

Guidehouse's work with utilities to analyze long-term weather hazard risk exposures and assess resilience investment plans, has demonstrated that robust benefit-cost analysis frameworks are important in allowing regulators and utilities to reach agreement and approve recovery of investments through rates.

– Peter Shaw

Guidehouse's work with utilities to analyze their long-term weather hazard risk exposures and assess their resilience investment plans, has demonstrated that robust BCA frameworks are important in allowing regulators and utilities to reach agreement and approve recovery of investments through rates.

Recently, new technologies are advancing utility approaches to resiliency planning. Utilities can now gather high quality visual data (such as satellite imagery), store large amounts of it, and process it into actionable insights through predictive analytics.

For example, the adoption of AI-driven tools like digital twin technology and machine learning software platforms will raise the bar for resilience investment planning and cost recovery. Many of these solutions are still in their infancy, but exponentially increasing and being validated through real-world application.

At the same time, our utility clients are bolstering their internal risk management functions and embracing resilience as a tent pole for galvanizing long-term corporate growth strategy. If the last ten years were the carbon-mitigation years, the next ten may be remembered for the industry's advances and increased emphasis on climate adaptation, risk management, and resilience strategy. ❍

How can utilities and regulators work in better concert with state-level programs tied to reducing greenhouse gas emissions?

Amul Sathe: The number of state-level programs aimed at reducing greenhouse gas emissions is growing. These new programs funded by federal or state taxes are running adjacent to many long-standing utility-funded energy efficiency programs. The existing programs result in greenhouse gas savings but were originally designed with the energy ratepayer's benefit in mind and are thus optimized to achieve different objectives and metrics.

More than twenty-five states have set energy efficiency goals for utilities, and state utility regulators oversee the achievement of these goals. Coordinated leveraging of strengths is the key to these programs working in concert.

The easy option may seem to be braiding state-level program funding with utility program funds to allow the dollars to stretch further. This allows state funds to leverage the existing localized networks of trade allies and contractors, which utilities have built over multiple years, and reduces market confusion from multiple programs from multiple sources.

However, mixing funds with different objectives can lead to downstream headaches in implementation, reporting, and evaluation. For example, state funds often come with broader scope and mandate than utility programs and have specific equity targets. Regulators must create certainty in program policy regarding utility program authority and how to track its impacts.

Where statewide programs are launched independently of utility programs, utility data access can open the door to a more effective program. Such data allows better participant targeting and increased accuracy in assessing and reporting the program's impacts and benefits.

– Amul Sathe

Where statewide programs are launched independently of utility programs, utility data access can open the door to a more effective program. Such data allows better participant targeting and increased accuracy in assessing and reporting the program's impacts and benefits. This kind of data sharing is only enabled through collaboration with utilities and often requires input or approval from a regulator regarding policies that govern utility customer data protection. ❍

What solutions do you envision for alleviating the transmission queue problem in the U.S. and what can utilities do to expedite distributed energy resource deployments in their territories?

Ed Batalla: The desire to integrate more renewable energy resources in the U.S. energy grid is causing a backlog of generator interconnection requests and associated transmission upgrades, so the processes are not keeping pace with the demand the energy transition is generating. Transmission is the grid's super-highway and can span large distances to bring generation supply from renewable sources – usually from remote areas – to areas where electric demand must be served. The current process of transmission development cannot keep up and is not process capable.

Transmission needs are often triggered by generation interconnection requests and require mandated studies to ensure proper

cost allocation for the new transmission facilities or for upgrades, or both. In July 2023, FERC issued Order No. 2023, which aims to streamline the generator interconnection process. This was a good start but will not solve the fundamental interconnection problems.

Key solutions include:

Creating more interregional coordination for large transmission projects, such as building capacity ahead of time and with incentives from viable market mechanisms.

Tightening alignment between interconnection and transmission planning processes.

Optimizing the process based on the generators' market participation, such as energy-only generators.

Using computing power and advanced techniques or models to reduce the cycle time for studies.

Accelerating the deployment of grid-enhancing technologies to maximize what can be gotten from the existing grid.

On the distribution level, utilities must also improve their efficiency in deploying and integrating DER. The typical approach of service planning on the distribution side is not process capable. Key solutions include:

In July 2023, FERC issued Order No. 2023, which aims to streamline the generator interconnection process. This was a good start but will not solve the fundamental interconnection problems.

– Ed Batalla

Incorporating DER adoption forecasts into the distribution planning times to anticipate needed upgrades.

Offering dynamic and readily accessible hosting capacity maps posted by the utility.

Streamlining the interconnection process so that prospective customers can self-serve. ❍

What actions are you seeing utilities take in response to the Inflation Reduction Act nearly two years after it was signed into law?

Jenny Hampton: Guidehouse is seeing utilities collaborate with State Energy Offices (SEO) on the Home Energy Rebates Program and Home Electrification and Appliance Rebate Program under the IRA by participating in stakeholder discussions and offering perspectives on overlapping incentives and program operations. While combining state-level program funding with utility program funds seems the easiest way to stretch dollars, mixing funds with different objectives can create problems in implementation, evaluation, and reporting.

Utilities want to leverage IRA funds to help meet their own climate and energy program goals, especially in historically underserved and complex customer sectors like multifamily and low- and moderate-income residences. They are also trying to figure out ways to ensure that the IRA programs do not create confusion among customers and their market's workforce.

Collaboration looks different depending on the state and the utility. If these programs are to work together, stakeholders must find ways to coordinate their strengths so they can leverage them.

In some areas of the U.S., utilities have been at the table since day one and are shaping the state's program design

alongside the SEO. In other areas, utilities are still waiting for the state to provide a channel for working together or are passively waiting for the SEO plan to be made available.

Whether active collaboration is happening or not, as the SEO plans become clear, utilities are beginning to map IRA HOMES and HEAR offerings to their own programs, so they can identify where alignment will be needed for program operations, such as marketing and engagement with trade allies. The industry is also continuing to work through specific and complex questions, such as attribution of program impacts, health and safety upgrades needed in homes before they can be made efficient or electrified, and how to address significant workforce gaps, both geographic and technological. ❍

Guidehouse is seeing utilities collaborate with State Energy Offices on the Home Energy Rebates Program and Home Electrification and Appliance Rebate Program under the IRA by participating in stakeholder discussions and offering perspectives on overlapping incentives and program operations.

– Jenny Hampton

Is digitalization happening fast enough at utilities, and are the current cyber protections adequate?

Keshav Sarin: Traditionally, the utility industry has been slow to adapt to the digitalization evolution. Utility business units remain mostly fragmented, leading to a lack of technology adoption organization wide.

Further, existing utility infrastructure and operational processes, networks, and systems have been slow to keep up with changing technology and the cyber threat landscape. Finally, the growth in DER and renewables has led to increased merger and acquisition activities for large utilities, which has caused more pressure on those utilities looking to be efficient and save operations and maintenance costs.

Digitalization is a necessary shift for utilities, and industries can take advantage of technologies to scale and implement state-of-the-art methods that deliver better products at lower prices with higher customer satisfaction. These technologies include lower cost of cloud computing and data storage, ML, and generative AI capabilities. Mature utilities are using these technologies to improve field dispatch operations, asset monitoring, and overall system reliability.

Cybersecurity attacks on all critical infrastructure sectors have increased over the past five years including the notable 2021 Colonial Pipeline ransomware attack. The International Energy Agency has reported that the critical gas and electricity infrastructure sectors were subjected to an average of 504 weekly attacks per organization in 2020, 736 in 2021, and 1,101 in 2022.

The AI and ML tools that cyber adversaries deploy are likely to increase the number, type, and success of attacks, so internalizing the lessons learned from high-profile cyberattacks and prioritizing cybersecurity by increasing investments are not enough. The industry must leverage next-generation security concepts, such as zero trust architecture for its IT/OT

The industry must leverage next-generation security concepts, such as zero trust architecture for its IT/OT networks, focusing on cybersecurity holistically and using the five pillars of security: identity, devices, networks, applications, and data.

– Keshav Sarin

networks, focusing on cybersecurity holistically and using the five pillars of security: identity, devices, networks, applications, and data.

Further, the industry must move to a security always-on model of cybersecurity controls implementation in which cyber controls are automatically and continuously checked. Finally, the industry will benefit from improving visibility for its IT and OT systems by implementing a single pane of glass to monitor security operations.

There is no silver bullet for cybersecurity. Rather, the solution lies in a combination of strong detective and preventive processes and tools, and a drive to evolve continuously with the changing threat landscape. ❍

With the finalized announcement of the Hydrogen Hubs late last year, what can utilities and regulators do to help achieve the 2030 clean hydrogen production goals?

Erik Larson: Clean hydrogen is an important tool in achieving a net-zero emissions future. To accelerate market development, the U.S. Department of Energy launched the Hydrogen Shot initiative in 2021 with an ambitious "1 1 1" goal to reduce the cost of clean hydrogen by eighty percent to one dollar per one kilogram in one decade, tapping into ten million metric tons of clean hydrogen production potential.

Meeting production goals requires a robust supply of reliable and low-cost clean energy coupled with long-term demand offtake certainty. Creating a viable marketplace requires customer education, pricing transparency, and economic distribution channels to accelerate demand.

Achieving this bold vision requires a fundamental shift in the energy landscape. Electric and gas utilities can play an essential role throughout this supply chain.

Customer-centric utilities should proactively engage with customers to understand their needs and explore innovative demand-side solutions. Utilities should engage with upstream producers to supply clean energy for hydrogen production, attracting a key source of new load growth with grid planning implications.

Transporting low-cost clean hydrogen from production sites to high-impact end-use sectors at scale (beyond co-located facilities) requires substantial investment in pipeline and storage infrastructure. Utilities can leverage or repurpose existing pipeline networks and rights-of-way to drive down the cost of high-volume distribution as the market matures.

The DOE Hydrogen Hub Program will lay a strong foundation for a national hydrogen economy, but without strong utility leadership and broad policy support, the Hydrogen Shot could miss its ultimate target.

– Erik Larson

To make this vision a reality, regulators and policymakers must work collaboratively with the nation's utilities to establish a regulatory framework that encourages participation, removes risk from utility infrastructure investments, streamlines permitting, enables innovative rate design, and promotes longer-term opportunities to decarbonize the power sector.

The DOE Hydrogen Hub Program will lay a strong foundation for a national hydrogen economy, but without strong utility leadership and broad policy support, the Hydrogen Shot could miss its ultimate target. ❍

The first "State and Future of Power" special issue was published six years ago, on June 15, 2018.

The Biden administration is pushing for vehicle electrification across the country. Do you think utilities and private industry can meet these goals? What key themes or challenges are you seeing among utilities working to meet the electric vehicle charging goals put forth?

Derek Jones: The transition of fleets, facilities, and fuels to new powertrains is transforming how we move people and goods around the globe, so the traditional boundaries of how vehicles are fueled, stored, and utilized are being redefined. National and state policies are critical to this mobility transition.

The Biden administration set a goal of fifty percent light duty electric vehicle sales by 2030 and backed that with new U.S. Environmental Protection Agency vehicle emissions standards to drive electric vehicle supply. Congress approved multiple electric vehicle charging infrastructure programs, including the five-billion-dollar National Electric Vehicle Infrastructure Formula program to roll out five hundred thousand charging stations.

These federal policies complement state policies, such as California's requirement for a hundred percent zero emission vehicle sales by 2035. Today, seventeen states and the District of Columbia have committed to following California's lead. Automakers, for their part, have committed to phasing out internal combustion engines in the next few decades, and in some cases, by 2030 (Volvo), in line with Biden's goal.

While policies are pushing EVs and infrastructure, utilities and private industry have critical roles to play. The NEVI program is an essential nationwide proof-of-concept for public charging infrastructure – but private investment BTM, alongside utility investment to the meter, are table stakes for ensuring that the mobility transition and Biden's goals succeed.

A key challenge to success is sufficient utility resources, such as energy, assets, workforce, and processes, to energize multi-megawatt electric vehicle sites in line with private sector electrification timelines – especially for supply chain fleets.

– Derek Jones

A key challenge to success is sufficient utility resources, such as energy, assets, workforce, and processes, to energize multi-megawatt electric vehicle sites in line with private sector electrification timelines – especially for supply chain fleets.

To achieve the infrastructure innovation marvel that is the mobility transition, utilities, regulators, private industry, and interested parties must not only collaborate, but they must also be willing to compromise and make mistakes in the interest of failing fast, so they can forge forward – and together. If investment in the mobility transition remains strong – both public and private – so does the prospect of a cleaner mobility future. ❍

In the first "State and Future of Power" special issue, published June 15, 2018, a From the Editor excerpt: When we assess the present state of power, and when we project the future, we know the states are really different … The electricity industry of the four new states – Hampshire, Jersey, Mexico and York – are on a variety of paths distinct from each other. And the four norths and souths – the Carolinas and Dakotas – have their own paths.

In what ways do you see AI having an impact on utilities over the next five to ten years? What are specific use cases you could see being piloted in the shorter term? On the demand side, how concerned should utilities be about the forecast power demand of AI for commercial usage?

Debbie Brannan: AI is set to bring transformative change to utilities over the next five to ten years and they should embrace the opportunities it presents. Two key areas of impact will be:

Enhanced grid management, because AI can predict and optimize load distribution in real time, reducing operational costs and achieving a more stable and resilient grid.

Predictive maintenance, because AI-powered systems can analyze vast amounts of data from sensors and meters, predicting potential failures before they occur, thus reducing downtime and maintenance costs.

In the shorter term, utilities should consider piloting customer service use cases that use AI-powered chatbots and virtual assistants to handle customer inquiries and complaints, leading to improved customer satisfaction and reduced operational costs. Testing high value use cases in the near term is an important way for utilities to begin demonstrating value and viability.

For utilities to fully recognize the business value AI can bring to their organizations, however, they must also invest in comprehensive strategic planning and capability assessments, upskilling and training their staff, and establishing AI governance policies and controls – as well as ethical frameworks.

The increasing use of AI in commercial settings on the demand side will indeed lead to higher power demand, particularly as AI applications involving deep learning and large-scale data processing are scaled up. Utilities should proactively engage with businesses deploying AI technologies, technology providers, and policymakers to ensure the grid infrastructure can support the increased demand from AI applications.

They should view this as an opportunity rather than a concern. The rise in power demand can be managed effectively by leveraging AI itself. Moreover, the increased demand could lead to innovative solutions in demand response programs, energy efficiency, and grid modernization improving utilities' services. Therefore, while utilities should be mindful of AI's forecast power demand, they should embrace the opportunities it presents. ❍

The rise in power demand can be managed effectively by leveraging AI itself. Moreover, the increased demand could lead to innovative solutions in demand response programs, energy efficiency, and grid modernization improving utilities' services.

– Debbie Brannan

On May 15, which was in the middle of the week, a Wednesday, demand for electricity totaled 11,339,064 megawatt-hours in the continental U.S. Of that total, 18.1 percent was in the Mid-Atlantic region, 16.5 percent was in the Midwest region, and 11.9 percent was in the Texas region, the regions as defined by the U.S. Department of Energy. Just these three regions accounted for nearly half of the total. None of the ten other regions – Northwest, Florida, Central, California, Southeast, Carolinas, Tennessee, New York, Southwest, New England – exceeded 8.7 percent by themselves.

How can utilities better encourage their customers to take advantage of state and federal home energy efficiency programs?

Robyn Link: With billions of home energy efficiency and electrification rebate dollars flowing from the federal government to SEOs, utilities are positioned to transform the energy industry by collaborating with SEOs to leverage their mature customer program infrastructures for maximum customer engagement and participation in home energy rebate programs. They can build out in three key areas:

Leverage contractors' existing networks and grow them. Contractors can help scale and accelerate in-field activities. They are often the first point of contact and already in communities introducing and providing customer support for energy efficiency programs. Utilities can help contractors prepare for customers by supporting outreach, education, and training, making federally required program tools available, and providing opportunities for the certifications required for delivering them.

Providing access to the treasure trove of customer data utilities collect can help contractors identify which customers will most likely benefit from home energy rebate programs. Contractors can use this data to determine which calculation methodology provides the greatest savings for customers and the grid. Utilities can also work with SEOs to establish security policies and processes for customer data consent and privacy.

To increase participation, make the customer experience easy. Utilities can add pathways to their existing application processes that allow for stacking and braiding of funds with existing utility and federal programs. Customers will have options for comprehensive energy efficiency improvements and can achieve greater energy savings.

Providing access to the treasure trove of customer data utilities collect can help contractors identify which customers will most likely benefit from home energy rebate programs.

– Robyn Link

Utilities can also work with SEOs, community-based organizations, and housing authorities on coordinated outreach and unified messaging that explains how customers can best access and benefit from the funds. This is especially important for ensuring that limited income customers have access to programs that would benefit them, since they may not have the time or availability to find these programs on their own.

With programs in the market, utilities are in an ideal role for meeting their customers where they are. They are best positioned to make these new rebate dollars more accessible, reducing energy costs and burdens for their limited income customers, while making their homes more efficient, comfortable, and future ready. ❍

How effective will FERC Order 2222 be at opening wholesale power markets to DER aggregations, and what will prevent its success?

Latisha Younger-Canon: When FERC issued Order 2222 in 2020, many considered the ruling a historic change enabling DER adoption to scale at a significant rate. Since that time, several barriers related to transmission scaling and distribution planning have led to sluggish growth, holding back the energy transition. While progress has been meaningful, Guidehouse is still not seeing transformative change.

In reality, Order 2222 in and of itself is not going to be the catalyst for change. Rather the catalyst is the rapid evolution of technology. Like a tsunami, it is coming and will be unstoppable. Even without

FERC 2222, Guidehouse has seen and continues to see the implementation of DER occurring in various segments. For utilities, the result is a limited window of opportunity for understanding and determining where best to position their organizations amid these changes.

Beyond reliability and resilience, utilities must balance their customers' needs with their businesses' interests, so understanding the requirements of FERC 2222, its potential business impact, and what would be most advantageous for a utility and its customers are critical to the utility's future health. For this reason, the consequences of inaction could be serious.

Guidehouse has been working to identify the challenges facing FERC 2222 implementation and supporting our utility clients in developing strategic plans for acting as an aggregator and market participant – allowing each to position its business as a player in the emerging DER landscape and extend its role beyond that of a traditional distribution utility, potentially realizing market revenue from participation.

In reality, Order 2222 in and of itself is not going to be the catalyst for change. Rather the catalyst is the rapid evolution of technology. Like a tsunami, it is coming and will be unstoppable.

– Latisha Younger-Canon

This approach ties together all aspects of the business – people, process, policy, and technology – to efforts to integrate aggregated DER into wholesale markets. Ultimately, the success of FERC 2222 will be contingent on the position utilities assume as the technological tide rolls in. ❍

What relatively modest investment could utilities make that would have the greatest impact on their long-term success?

Nathan White: In the ever-evolving utility landscape, a strategic shift toward a customer-centric mindset can unlock long-term success. This approach places customers at the heart of every decision, process, and interaction, and transforms the traditional focus on reliability and affordability into a holistic view of customer needs.

The first step in this cultural shift is fostering a mindset in which employees view their work through the lens of customer impact. Leaders must invest in their staff, ensuring they have the necessary processes, organizational structure, and authority to apply new technologies and understand evolving customer needs. This shift from viewing customers as ratepayers to a customer-obsessed culture requires deliberate effort across the enterprise.

As customers make progress on their decarbonization journeys, utilities are uniquely positioned to understand their needs. Customer analytics can provide insights into customer behavior, preferences, and pain points, allowing utilities to develop new offerings that meet emerging needs. This data-driven approach can help

utilities stay ahead of the curve and ensure they can balance the many competing priorities and constraints on the grid.

With an increasing amount of customer data available, investing in areas such as process improvement, change management, and training can enable teams to make efficient use of data. Additionally, incorporating roles such as data scientists, business analysts, and leveraging low code platforms in business, ensures teams have the necessary skills and resources to maximize the value of customer data.

Promoting cross-functional collaboration and breaking down historical silos can also play a significant role in this cultural shift. By creating common goals and cross-departmental metrics, utilities can ensure a more cohesive and customer-focused approach.

By placing customers at the heart of every decision, utilities can unlock benefits that extend beyond the balance sheet and ensure they succeed in the industry's dynamic landscape.

– Nathan White

Investing in a customer-centric culture is more than just a buzzword; it is a strategic shift that can position utilities for long-term success. By placing customers at the heart of every decision, utilities can unlock benefits that extend beyond the balance sheet and ensure they succeed in the industry's dynamic landscape.

What can utilities do to prepare their regions for the workforce they will need in the future? What ancillary benefits have you seen from these types of programs?

Shaun Fernando: The main change to future regional workforces will be the continued decoupling of labor productivity from economic growth, due to continued adoption of technological innovation in multiple industries and sectors. This is exacerbated by AI.

While this decoupling will create economic benefits and increase shareholder value, it potentially leaves serious questions about the utilization and fulfilment of human capital at the regional and community levels. Future workforces must therefore work alongside AI and be flexible enough to reconfigure and find new roles for labor's skills and experience.

This reconfiguration will require a workforce of generalists, who have transferable technical skills and can work at the business-technology-customer interface. This workforce will need sufficient technical skills to modify – or tinker with – software applications, enough business acumen to regulate workflows and manage projects, and plentiful soft skills to flexibly respond to changing conditions or customer needs.

Utilities must not be simply a labor market's end users, but they must be active agents in setting demand and defining the marketplace's parameters for workers' relevant skills and experiences.

– Shaun Fernando

Utilities have a unique role to play in workforce development, from the enterprise standpoint of their own workforces and from the perspective of skills uplift in the communities they serve.

From an enterprise standpoint, utility workforces are presently structured largely around a core of high utilization, long-serving role-focused, and task-focused workers, supplemented by lower utilization contract workers for specialized needs.

Future utility workforces must have a lower cost, fungible workforce that is cross trained across multiple disciplines

and tasks that can complement technology tools and build in resilience through role switching.

From a community standpoint, utilities play the same role that other industries and employers do: They define the skills, competencies, and body of knowledge required for employment. The larger systemwide challenge is a misalignment between the skills output from K-12 and higher education institutions with those skills an industry actually needs.

Utilities can address this misalignment by, for example, sponsoring tertiary or higher education programs to codesign curricula and functional experiences representative of the types of skills needed in the workplace. They can also provide internship or placement-year opportunities for those students with relevant technical backgrounds.

A key barrier to the energy transition is the limited supply and elasticity of trained workers necessary to design, build, and operate future technology and management systems. The adoption of technology tools that offset human labor compounds this challenge.

In response, utilities must not be simply a labor market's end users, but they must be active agents in setting demand and defining the marketplace's parameters for workers' relevant skills and experiences.

This is a new proposition for many utilities, but – as with many other paradigm shifts – it is one for which they may need to step away from orthodoxy and work asymmetrically into a complex and fragmented ecosystem that can ultimately deliver a technology-literate, fungible, and elastic workforce. ❍

What steps should utilities take today to harden their infrastructure and better prepare for extreme weather?

Aditya Ranade: Utilities should begin by mapping what extreme weather events – floods, hurricanes, storms, wildfires, and extreme heat – are most consequential to their territories by correlating their operational data with historical weather data.

The next step is forecasting how extreme weather events are likely to change in different times. Determining the appropriate time for each decision is critical. For example, a typical integrated resource plan looks out fifteen years, but a climate risk disclosures requirement at the enterprise level may necessitate a thirty-year outlook.

After determining the appropriate time and relevant hazards, utilities can decide from an array of available public and private tools for natural hazard forecasts. After developing those forecasts, utilities should determine which of their assets are most vulnerable and which adaptive actions make the most cost-benefit sense.

A typical integrated resource plan looks out 15 years, but a climate risk disclosures requirement at the enterprise level may necessitate a 30-year outlook.

– Aditya Ranade

Undertaking these foundational steps will set up utilities for success whether they are filing a resilience plan, a rate case, a resource plan, or an enterprise-wide climate-risk disclosure. ❍

As the director leading Guidehouse's Energy System Decarbonization Solutions team, **Danielle Vitoff** leads teams developing decarbonization and climate resilience solutions for utilities, Fortune 100 companies, and U.S. cities. Danielle constructs strategies that position clients for success in the complex and changing landscape of climate and sustainability. Danielle is adept at managing diverse stakeholder networks, exposing underlying drivers, and driving forward strategies with wide support. Notable engagements include leading the development of the San Antonio Climate Action and Adaptation Plan, building decarbonization roadmaps for multiple natural gas utilities, serving as the lead author on a first-of-its-kind report for the American Gas Foundation: "Building A Resilient Energy Future: How the Gas System Contributes to US Energy System Resilience," and the development of a science-based target for The Coca-Cola Company.

Peter Shaw is a director in the Energy, Sustainability, and Infrastructure segment, where he leads a team of experts in Regulatory and Pricing Strategies. His clean energy

How can C&I users reduce their impact on the grid during their electrification process? How are you seeing utilities manage this increase in demand across the board?

Steve Waller: C&I consumers are facing the twin challenges of navigating the incredible surge in demand from their customers and the emerging imperative around decarbonization and electrification. From electric battery production to microchip fabrication, Guidehouse is seeing unprecedented energy demand from all sectors of the economy.

Recently, FERC has estimated that electricity demand will increase by 4.7 percent over the next five years, growing by more than thirty-eight gigawatts. To respond to the market need while continuing to decarbonize and electrify operations, C&I consumers must take a number of actions including:

Acting now; do not wait for others to move first.

Adopting an end-to-end value chain approach.

Accelerating the implementation of low carbon tech and infrastructure.

Building green premiums into financing and investment requirements.

Even before addressing the question of increasing demand, remember that running a utility's operation is challenging, especially with the aging infrastructures often in place, and that most of Guidehouse's clients in the Midwest are facing complex regulatory environments.

For those reasons, the industry is still figuring out how to balance supporting dramatic increases in demand with driving the transition to clean energy. A few common themes emerging across Guidehouse's clients are:

Doubling down on grid modernization.

Strengthening risk, reliability, and resiliency analytics.

Aligning supply chain requirements and expectations in the context of CAPEX planning.

Investing in more rigorous system planning.

Strengthening partnerships across the energy value chain – including with regulators. PUF

C&I consumers are facing the twin challenges of navigating the incredible surge in demand from their customers and the emerging imperative around decarbonization and electrification.

– Steve Waller

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transition advisory work for electricity and gas utilities focuses on regulatory compliance and innovation strategies for achieving greenhouse gas mitigation, climate risk management, and corporate resilience. Previous to joining Guidehouse, Peter's energy industry work included senior strategy roles at EY-Parthenon, J.D. Power & Associates, and cleantech startups in demand response, AI/machine learning, and industrial energy services.

Amul Sathe is a director in Guidehouse's Western Market Region, primarily serving clients in California. For more than fifteen years he has helped utility regulators and state energy offices advance policies, markets, and technologies to achieve ambitious carbon reduction goals. Amul oversees the development of forecasting models, analytical tools, and market studies that are used to inform energy goal setting, grid planning, R&D investment decisions, and program design in the fifth largest economy in the world.

Ed Batalla is a director in Guidehouse's Energy, Sustainability, and Infrastructure segment, delivering full lifecycle solutions to transform energy systems, markets, transmission, and distribution planning & operations processes, and infrastructure, assets, and technologies for a more sustainable, resilient, and secure energy system. Ed has a strong track record that spans more than thirty years in the electric utility and energy industry environments and associated technologies. Ed assists energy, utility, and governmental clients in crafting their energy transition strategy, vision, and mission, leveraging the integration of new technologies to adopt their business and organization.

Jenny Hampton is a partner at Guidehouse with twenty years of experience helping utilities and governments design, deliver, and

evaluate their customer-facing clean energy programs. She currently leads the Guidehouse Customer Program Evaluation team and directs the evaluations of several large U.S. utility customer program portfolios. Before joining Guidehouse in 2011, Jenny spent four years with the Colorado State Energy Office, where she oversaw the office's public outreach and energy rebate program marketing strategies during the Recovery Act.

Keshav Sarin leads the cybersecurity and compliance solutions in Guidehouse's Energy, Sustainability, and Infrastructure segment, helping clients in commercial, state, local government, and federal agencies with cybersecurity strategic and implementation guidance. Keshav brings more than twenty-eight years of professional experience in a variety of cybersecurity roles related to risk management, information systems development, and security controls management.

Erik Larson is a director in Guidehouse's Energy, Sustainability, and Infrastructure segment, leading decarbonization go-to-market initiatives such as clean hydrogen, e-mobility, and other sustainable infrastructure solutions. With a passion for building transformational energy solutions, Erik partners with utility executives to develop and operationalize customer-centric strategies and achieve sustainable excellence.

Derek Jones is a director in Guidehouse's Energy, Sustainability, and Infrastructure segment, where he leads the Mobility/EV Service. Derek has more than fifteen years of experience in the transportation and energy sectors. Derek manages teams bringing direct industry experience and proven consulting expertise, to develop outcome-based solutions for a sustainable mobility future. He supports market actors across the ecosystem – including utilities and energy providers, automakers, investors, and governments – in developing and delivering innovative mobility programs, products, and services.

Debbie Brannan, Ph.D., is a director in Guidehouse's global Energy, Sustainability, and Infrastructure practice. As a leader of the Data & Analytics Solutions team, she brings more than ten years of experience developing analytics solutions that enable energy companies and governments to make data-driven decisions amidst a rapidly changing industry and a digital revolution. Debbie has expertise in customer-facing energy programs, supporting clients in delivering programs with a focus on emerging technology, including EVs, storage, and the IoT.

Robyn Link is a director within the Energy, Sustainability, and Infrastructure segment, where she leads the Customer and Citizen Programs Design and Delivery teams. She has twenty-one years in the energy industry. Robyn has partnered with eighty-plus utility companies (IOUs, Co-ops, and Municipals) in North America to create and deliver new, transformational load management and customer engagement solutions that drive results and resolve significant business challenges for utilities.

Latisha Younger-Canon works at the forefront of customer experience across nearly all aspects of the energy industry. She is deeply invested in understanding what makes customers and clients tick, how to draw out feedback, find actionable solutions, and solve real-world problems. Her experience in energy covers both regulatory and non-regulatory utility operations. She is an expert in demand-side management programs, having worked extensively in program evaluation, design, and implementation for more than thirty utility clients. Currently, she spends her time leading business development efforts tied to customer programs and initiatives and overseeing delivery operations for large-scale energy provider projects in the South Market of the Energy, Sustainability, and Infrastructure segment at Guidehouse.

Nathan White is a director at Guidehouse with fifty years of experience in the successful management of complex program deliveries, with a focus on emerging technologies, sustainability, energy transition, operational efficiency, intelligent products, and analytics. An expert in transformational projects, he brings a diverse background to co-create holistic and innovative solutions that drive meaningful and measurable impact.

Prior to his career in consulting, Nathan oversaw the design and management of billion-dollar capital programs and portfolios, for utility clients, with a multinational engineering firm. Nathan received his BS in Industrial Engineering from Clemson University.

Shaun Fernando is a partner at Guidehouse, leading strategy and economics consulting services, working with governments, utilities, transportation agencies, and the private sector on a range of strategic and public policy initiatives – specifically in the areas of economic development and industrial policy, climate change and net-zero decarbonization, and broadband and connected communities. Shaun sits on the eight-member Economic Roundtable for the Southern California Association of Governments, the federally mandated planning organization for the region. Shaun is also a Fellow at the Atlantic Council, advancing the council's agenda on the net-zero economy and social capital.

Aditya Ranade has eighteen-plus years of experience in public and private sectors serving corporations, utilities, investors, and government officials. Currently he leads the Infrastructure Resilience Solutions team for Guidehouse serving energy providers and he specializes in natural hazard/climate resilience, grid modernization, and regulatory policy. He holds a PhD in Material Science and Engineering from Case Western Reserve University and an MBA from Babson College.

Steve Waller is a transformational strategy, operations, and technology executive who works with management teams and boards of directors to drive sustainable value through growth strategies, operating model designs, structural cost resets, and technology-driven transformations. Most recently, Steve led Accenture's Midwest Resources Industry Strategy & Consulting business. Beyond the energy value chain, Steve has worked with industrial, chemicals, and manufactured products clients on large-scale M&A and complex transformations in North America, Europe, and Latin America.

> The first "State and Future of Power" special issue, published June 15, 2018, featured the perspectives of eight Commissioner Chairs and a dozen experts from Navigant Consulting (now Guidehouse).

Electric Bills As Percent of Households' Total Expenditures

Consumer Expenditure Survey, 2023 Mid-Year

In May, the Bureau of Labor Statistics released the microdata for the Consumer Expenditure Survey for 2023 Mid-Year. The Consumer Expenditure Survey is the gold standard for understanding the expenditure patterns of American households. Since 1984, it engages thousands of households each year in detailed reporting of every expenditure on all goods and services including their payment of electric bills.

This table illustrates the differences between households for which their electric bills are the highest percentage of their total expenditures and households for which their electric bills are the lowest percentage of their total expenditures. The comparison shows that households with the highest electric bills percentage have far less income on average, are generally older and have fewer earners, and are more likely to be headed by a female, to be headed by a black individual, and to reside in rural America. They are less likely than average to reside in California and more likely than average to reside in Texas and Florida.

This table should be used for comparison purposes only. The microdata is very helpful for understanding these kinds of differences. But they do not represent the statistical weighting that the Bureau of Labor Statistics will carefully apply when it publishes its annual tables for the Consumption Expenditure Survey.

For example, this table has the overall average of electric bills as a percentage of total expenditures at 3.4 percent for the four thousand households. After excluding high-tail and low-tail households in the distribution. When properly-weighted, the annual tables will typically show the overall electric bills percentage for all American households at around 2.3 to 2.5%.

	Bottom Thousand Households	All Four Thousand Households	Top Thousand Households
Average Electric Bills % Total Expenditures	**1.0%**	**3.4%**	**6.5%**
Average Income After Taxes	$131,956	$94,487	$59,134
Average Age (Reference Person)	50.1	53.5	57.1
Average Number of Earners	1.5	1.3	1.1
% Female (Reference Person)	45.7%	50.0%	55.1%
% Black (Reference Person)	7.3%	10.2%	13.3%
% Rural	4.4%	5.8%	8.7%
% California	16.0%	12.5%	10.5%
% Texas	3.5%	5.8%	8.4%
% Florida	2.7%	5.8%	8.7%

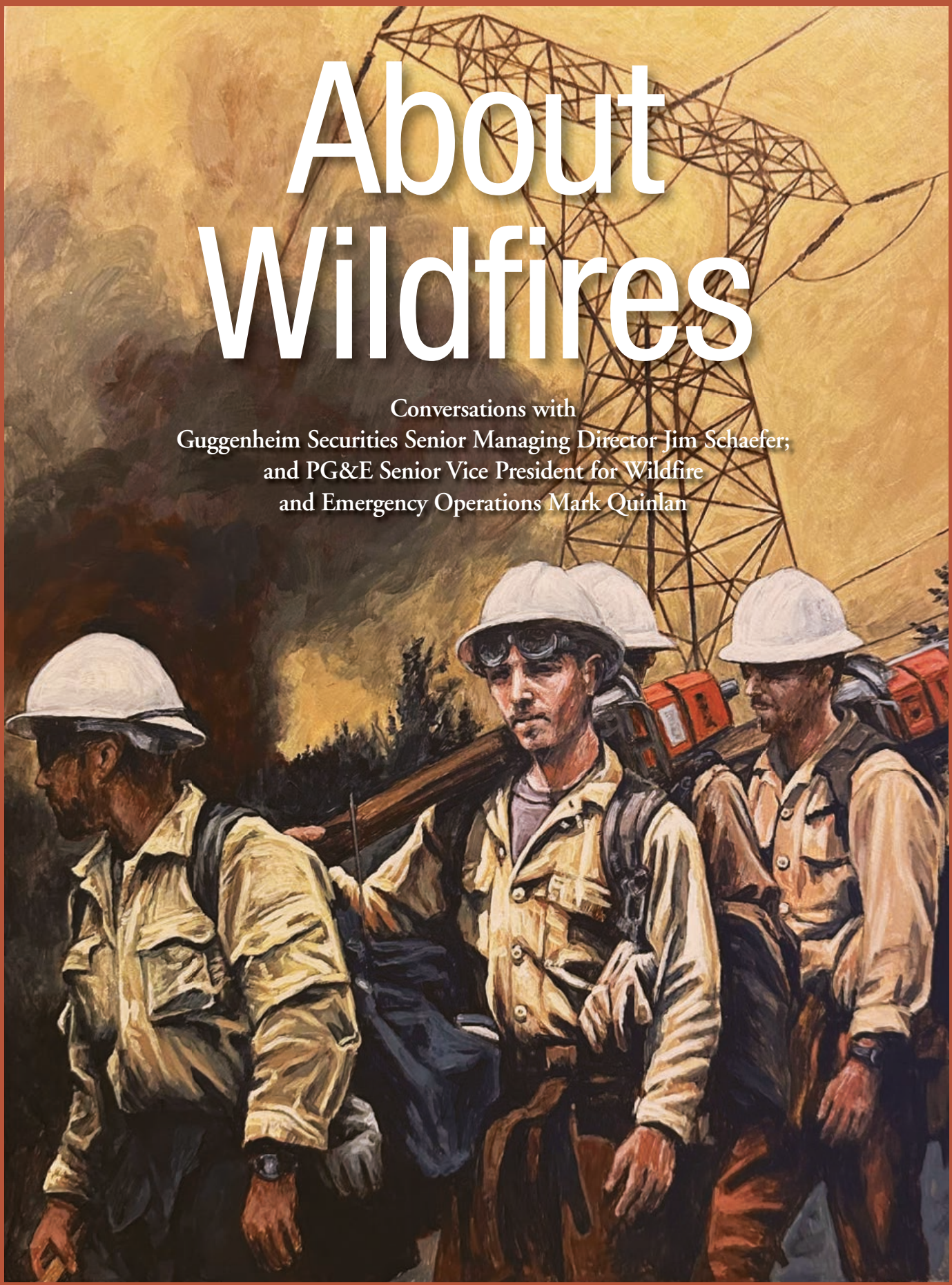
Source: Bureau of Labor Statistics, U.S. Department of Labor
Analysis by Public Utilities Fortnightly Staff

Extreme tails of the distribution at the upper end, comprising three hundred and eighty five households, and lower end, comprising three hundred and eighty five households as well, were excluded from the analysis.

Reference Person is defined by the Bureau of Labor Statistics as "the first member mentioned by the respondent [in the Consumer Expenditure Survey] when asked to 'start with the name of the person or one of the persons who owns or rents the home.'" PUF

About Wildfires

Conversations with
Guggenheim Securities Senior Managing Director Jim Schaefer;
and PG&E Senior Vice President for Wildfire
and Emergency Operations Mark Quinlan



Wildfires, unfortunately, are increasingly becoming an issue for energy and utilities companies. Well-known fires have names such as the Camp Fire in California or the Lahaina fire in Maui, but there are too many more all over, in places like Canada and even Virginia recently.

It is a utility-wide problem and one that is expected to increase. Of course, utilities have been coming up with new ways to defend against wildfires but there is a cost.

Utilities now have public safety power shutoffs and design systems with sensors, so if fire meets the line, it automatically de-energizes as fast as one-tenth of a second. Expect that arsenal to grow, even with improvements in vegetation management and undergrounding of lines.

It also means that individuals have become experts on issues having to do with wildfires. Public Utilities Fortnightly's Paul Kjellander and Steve Mitnick spoke with two of them. There is much to learn, and Guggenheim Securities' Jim Schaefer and PG&E's Mark Quinlan shared wisdom on these difficult issues.

Jim Schaefer

Guggenheim Securities Senior Managing Director, Head of Energy Investment Banking

PUF's Paul Kjellander: Catastrophic wildfires are a major concern for many utilities across the nation. How does the investment community respond to risks utilities are exposed to?

Jim Schaefer: First, we've had a series of unprecedented wildfire events. During the last decade in particular, a number of catastrophic events have taken place in areas that had not been subject to wildfires previously. The number of events, the magnitude of impacts on local communities, and the degree to which utilities are now being blamed for and subject to liabilities are new to investors.

Second, in response to these events, utilities are actively developing, deploying, and measuring services and technologies that can help prevent wildfires and also reduce risks. As a result, the investor community now understands the risks and is focused more on what utilities are doing to address those risks.

The third area, and probably the most important one longer term, is that investors are focused on whether a long-term solution can be implemented to limit liabilities around wildfires. One pathway may involve limited liabilities at the state and/or federal levels.

Another pathway may involve the creation of federal, regional or state wildfire funds that create a buffer zone around utilities. For example, the State of California has taken a big step in creating a wildfire fund, which Guggenheim helped arrange.

We advised the governor's office around the PG&E bankruptcy and took the lead in establishing the fund. The risk exposures are serious in investors' minds, and they are looking for steps to be taken both within utilities and outside utilities to help address them.

We cannot have utilities with unlimited liability exposure to wildfire events. It is critical that utilities have abundant access to low-cost capital to fund the reconstruction of the grid.

PUF: What do utilities need to do to demonstrate to the investment community that they are appropriately addressing the risk?

Jim Schaefer: I see tremendous coordination amongst utilities in sharing information around what they each perceive to be best practices and the steps that need to be taken in their respective jurisdictions to ensure wildfire risks are mitigated. Some of these steps include significant capital expenditure plans to help those best practices move from concept to implementation.

Additionally, utilities need to continue communicating their progress to customer bases, regulators, politicians, investors, and rating agencies.

Time is of the essence. There are many technology and service breakthroughs. Examples include transmission/distribution and monitoring upgrades, pole replacement, undergrounding power lines in certain locations, and real-time dropped line monitoring.

These measures go hand-in-hand with sensible Public Safety Power Shutoff (PSPS) plans that involve communicating to customers the risks and mitigation strategies. Customers will need to understand and prepare for when there's high wildfire

We must have liability caps. It may seem unachievable to change state and/or federal laws, but utilities' exposure to these liabilities must be capped. Customers are being impacted by legal costs associated with wildfires. Unless reasonable limits are placed on wildfire liabilities, access to capital will be hampered.

risk, high wind, and storms, that unfortunately may result in power needing to be shut down.

PUF: In terms of hardening systems for resiliency, when there's pressure on utilities to get capital for the energy transition, does wildfire mitigation take precedence? Can both be done?

Jim Schaefer: To harden the grid, but also to provide one hundred percent clean electrons, it's going to be expensive, and I believe that the public has yet to fully realize the costs. But the long-term cost of not having a hardened grid and a clean grid is going to be far more expensive.

We cannot have utilities with unlimited liability exposure to wildfire events. It is critical that utilities have abundant access to low-cost capital to fund the reconstruction of the grid.

On the energy transition side, to have clean power, especially clean baseload power, new technologies are needed including new nuclear, hydrogen, carbon capture and sequestration, as well as direct air capture. While these technologies carry initial startup costs and risk, once established the capital costs will come down and allow for abundant opportunities to invest in these critical technologies.

Education around these issues is key in order to obtain customer buy-in, commission support, and political direction.

PUF: What about the legal structure as it relates to catastrophic wildfire and what might be some avenues to consider looking at?

Jim Schaefer: Let me be blunt – we must have liability caps. It may seem to be unachievable to change state and/or federal laws, but utilities' exposure to these liabilities must be capped. Already, customers are being impacted by legal costs associated with wildfires. Unless reasonable limits are placed on wildfire liabilities, access to capital will be hampered.

PUF: What message do utilities need to hear?

Jim Schaefer: Because customer outreach and education with key stakeholders are so important, communication about progress being made and about steps that need to be taken in the future are fundamental to utilities having success in mitigating these risks.

This industry is impressive in its ability to cooperate around storm damage. We are witnessing similar coordination around these wildfire risks, as well as the clean energy transition.

Utility management teams have a long history of taking appropriate steps to provide reliable, low-cost, and clean power. I am optimistic about utilities' abilities to lead the change required to address these challenges.

PUF: What is important that we missed?

Jim Schaefer: We have to look at this wildfire challenge as an opportunity. While utilities are busy addressing wildfire risk, they are also taking steps to harden the grid in other ways. New clean energy technology, as an example, can be robust and impermeable to extreme environmental events.

Our economy will be increasingly electrified in the coming decades. That is an incredible opportunity to make our planet cleaner, more functional, and safer.

Personally, there's never been a better time to cover the power sector. It's an honor to work with these companies, and my team and I try to be a big part of the thinking that goes on in the wildfire and clean energy arenas. ❍

Mark Quinlan

PG&E Senior VP of Wildfire, Emergency, and Operations

PUF's Steve Mitnick: Give an overview of what you do at PG&E.

Mark Quinlan: I have the privilege to lead the Wildfire, Emergency and Operations teams at PG&E and I'll do my best to break it down for you.

Starting with Wildfire, my team and I are responsible for PG&E's wildfire mitigation plan. What this means is everything we do in this space, filing of the plan, execution of the commitments associated with the plan – we have oversight and are accountable for. Examples include our asset-based work like undergrounding, system hardening, vegetation management, and system inspections.

I also oversee our operational mitigations, including our Public Safety Power Shutoff and Enhanced Powerline Safety Settings programs. Our Wildfire Risk, Meteorology and Fire Science teams are a big part of this group.

Shifting to Emergency, my team and I responsible for our Emergency Preparedness & Response function for PG&E. This is an all-hazards preparation and response portfolio, which includes hazards like wildfires, earthquakes, severe storm events, cybersecurity events, pandemics; anything that can threaten the company.

We have a Hazard Awareness and Warning Center that is constantly monitoring conditions and identifying anything that can threaten the company or the safety of our coworkers. We manage our business continuity plans, as well. I serve as one of our Incident Commanders in the Emergency Operations Center and lead all our Public Safety Power Shutoff events.

Last, but not least is Operations. We are responsible for the day-to-day operation of PG&E's transmission and distribution grids. This is accomplished through two Transmission Control Centers and three Distribution Control Centers, where all planned and emergency work that takes place on the system each day flows through.

This includes equipment from five hundred kilovolt transmission lines down to the secondary service that serves a residential customer. The team also includes operations engineers and operational technology like SCADA, ADMS, and DERMS. Our wildfire operational mitigations are also all executed here.

Nearly 50% of our 70,000 square-mile service territory is considered elevated or extreme wildfire danger, so we need to think differently with respect to how we operate the T&D systems.

PUF: PG&E's T&D system is vast, complex, and increasingly so because of distributed generation and all the changes coming.

Mark Quinlan: Yeah, it sure is, and it's massive. Nearly fifty percent of our seventy-thousand square-mile service territory is considered elevated or extreme wildfire danger, so we need to think differently with respect to how we operate the T&D systems.

As you mentioned, there are changing characteristics of the grid due to renewables, distributed energy resources, building electrification, new data center load, and electric vehicles.

It would be difficult enough to operate the system with all these new challenges coming at us, but in California we also need to factor in threats like wildfires, storms, and earthquakes. It makes this an exciting time to be in the business but requires leadership that has to support breakthrough approaches and new ideas.

PUF: People want to hear about your journey. What are the best practices? You've become a proselytizer on this important subject.

Mark Quinlan: I appreciate that acknowledgment. I'm humbled by it. Like many others, I grew up in this industry, trying to keep

the lights on, getting them back on if they were out, as safely and quickly as possible, and responding to emergencies.

Reliability and customer satisfaction have always been a priority, as is doing everything to have a good performing system. When I came to PG&E, the first couple of years were a learning experience on how to operate in California, compared to what I had learned in the Chicago area of Illinois.

A lot of the operating practices are the same across the nation, however my job fundamentally changed in 2017 with the emergence of wildfire in northern California, largely driven by extreme weather conditions.

We experienced multiple wildfires in our service territory from 2017 through 2022, some of which were tied to our equipment. Beginning in 2018, we established a Community Wildfire Safety Program that focused on standing up efforts like wildfire system inspections, vegetation management, and system hardening.

In parallel, we began installing weather stations, wildfire cameras, and introduced our Public Safety Power Shutoff program. In the years that followed, we installed hundreds of sectionalizing devices on the transmission and distribution systems, to be able to better isolate sections of our systems during PSPS events.

Significant improvements to our meteorology models, coupled with this additional operating flexibility via the sectionalizing devices, resulted in our ability to become more granular when scoping and executing PSPS events. This ultimately meant de-energizing less customers, while adequately addressing the wildfire risk.

A dedicated effort to underground ten thousand miles of our highest risk circuits and implementation of our Enhanced Powerline Safety Settings program followed.

Fast forward to 2023, no fires of consequence and our overall ignition trends are way down compared to 2017 levels. PG&E had a nice year in 2023 and is positioned well for 2024. We're continuously improving but don't suggest we have all the answers.

But what we do have are lessons learned to share with our peers who have wildfire risk in their service territory, or who will have it in the next five to ten years, as our environment continues to change and forces us to adapt to the conditions.

The key for me is speed, to get there quickly, to create that margin of safety as quickly as possible. In retrospect, I would first start with implementing operational mitigations and then add the infrastructure improvements, inspections, and targeted vegetation management shortly thereafter. The reason for this is speed and cost.

Operational mitigations can be put in place within a year or two, while the asset improvements take longer to execute over multiple years. The two approaches go hand in hand and in time as the system becomes more resilient, the need to rely on, and implement, operational mitigations will decrease.

The most-effective wildfire operational mitigations and cheapest to implement, are Enhanced Power Line Safety settings or fast trip settings, coupled with disabling automatic reclosing. You've got to have a PSPS program. These are the most effective tools in the toolbox.

These are both informed by meteorology capability, situational awareness with weather stations, and high-definition cameras. A lot of meteorology and fire science gives us the ability to see the threat coming, posture the system accordingly, and communicate effectively with stakeholders.

Communication with stakeholders is critical, both during an event, as well as throughout the season. State agencies, county agencies, public safety partners, cellular providers, critical infrastructure customers, and elected officials all need to be included in the communication plan, so we can all see this threat coming and can prepare to protect people.

It's important to share lessons learned and do everything we can to encourage utilities to our east to get prepared.

PUF: Do you feel like there're still things to learn and seek to get better on?

Mark Quinlan: Absolutely. By our internal calculations, we have ninety-four percent of the wildfire risk mitigated through our programs. There's still six percent to go, and that is going to take work.

There are opportunities to improve and advance. A lot is contingent upon new technologies and capabilities, whether it's a part of the electric system, like protective equipment or devices, or with respect to situational awareness.

The majority of our wildfire mitigation efforts, we refer to as layers of protection, and are designed to prevent ignition from happening. We're also looking at post-ignition layers of protection, effective mitigations that can be applied if an ignition still occurs. This is where technology can play a big role.

We've got over a thousand wildfire cameras in the State of California, and PG&E sponsors more than six hundred of them. They've all, since last year, had AI implemented.

We're starting to see the positive impacts of AI with the ability for wildfire cameras to pick up a real fire, and not fog, not the marine layer coming in from the coast, not something that looks like fire to the human eye but isn't. The AI hits are picking this up well.

CAL FIRE is dispatching first responders to incidents off AI hits. That means CAL FIRE can catch these fires when they're small, execute initial attack, and knock these fires down. They're not relying on humans to pick up the phone and call 911. Given the effectiveness of the AI cameras, we plan to install more of them.

PUF: You have incredible innovation when it comes to wildfires.

Mark Quinlan: Yes. These are extraordinary times, so they

What we do have are lessons learned to share with our peers who have wildfire risk in their service territory, or who will have it in the next five to ten years, as our environment continues to change and forces us to adapt to the conditions.

require extraordinary thinking and partnerships. We've got standards, procedures, safety rules, and all these types of things that have been put in place over a long period of time due to safety events, lessons learned, and operating experience, as they are in most utilities.

But with the changing conditions in California and the associated wildfire risk, it requires us to operate our system completely differently based on where we are in the wildfire season. Innovative solutions are a must.

An example of that for us was implementation of our Enhanced Powerline Safety Settings program, and then continued improvement and evolution of the program based on lessons learned. EPSS is our fast trip program, where we adjust the clearing speed of our protective devices to clear faults within a tenth of a second.

This program started as a pilot in 2021 on nearly two hundred of our highest risk distribution circuits and was so successful from an ignition reduction perspective, that we decided to expand it to over one thousand circuits that exist in, or are in close proximity to, our high-fire-risk areas.

EPSS is a combination of disabling automatic reclosing and applying fast tripping that was lab-tested at our internal research facility. We apply it on all our high-risk circuits and enable or disable the settings based on advanced meteorology data, namely wildfire fuel conditions, relative humidity levels, and wind speeds.

Each circuit has a custom settings plan based on the design of the circuit. We make the decision to put that plan into action each day based on the fire weather conditions. We've had much success with the program and are seeing ignition reductions in the neighborhood of seventy percent compared to 2017.

Even with that success, we noticed that EPSS was not detecting high-impedance faults, which are those faults that have low levels of fault current and look like load to the protective device. As such, we implemented Downed Conductor Detection or DCD, which uses sophisticated harmonic analysis to detect arcing that may be present during a high impedance fault.

DCD provides immediate tripping when this occurs, and we believe we prevented seventeen ignitions in 2023 by enabling this additional layer of protection.

There are new sensor technologies that could help predict failures before they occur. They help us see at a more granular level of detail, the way our system operates. These sensors have the capability to detect anomalies and potential problems on the system.

Then folks can be dispatched to have a look at the equipment before it fails, instead of responding to an outage or failure. An outage or an equipment failure at the wrong time of year could be an ignition.

The challenge for utility operators is to figure out how to package different technologies and operating practices together to make it all work. There is no one-size-fits-all solution, as we all have different system designs and different risk potential in our service territories. The key for me is sharing what is working and what isn't, collectively across our industry.

In addition, there is a lot of interest outside our industry in trying to solve the wildfire problem. One example is the XPRIZE Wildfire competition we are cosponsoring with the Gordon and Betty Moore Foundation.

The competition has two tracks. The first track is space-based recognition of wildfire ignitions within one minute across a massive landscape the size of states or countries, with ten minutes to accurately characterize all fires and report accurate data to the folks on the ground.

The second track is autonomous wildfire response, where teams have ten minutes to autonomously detect and suppress a high-risk wildfire, while leaving decoy fires untouched. That is innovation.

PUF: Talk about the people internally and externally that you're trying to build this new foundation on.

Mark Quinlan: I'll start internally. I love my coworkers. Who doesn't love utility people? I'm starting year thirty-four in the business, and what we all do every day, the dedication, the commitment, you don't realize how much of a public servant you've become over your career.

We were trained to keep the lights on, not shut them off on purpose. But catastrophic wildfires changed all of that and forced us to think completely differently with respect to operating our transmission and distribution systems. The PSPS program was very difficult for us to get used to, from leadership out to the front line.

It was a total shift in thinking and realization that we had to do something different to protect the public. Since 2018 when the program was created at PG&E, we've executed a total of twenty-three PSPS events successfully, with no catastrophic wildfires occurring during the high-risk periods. Each time we execute successfully, we gain more confidence in the program, as do our customers.

The Enhanced Power Line Safety Settings Program came into play in 2021 as a pilot. When we first implemented EPSS, it was challenging for our coworkers to understand, similar to the PSPS experience. With EPSS, instead of shutting off power intentionally, we're deliberately adjusting protective relays to operate incredibly fast to reduce the arc energy at a fault location with the intent to prevent ignitions. It's working very well.

Both programs have reliability impacts and required a shift in thinking by our coworkers. Now, wildfire safety is in the fabric of how we operate the system.

From an external perspective, in my view, it starts with having discussions about wildfire risk, starting with my peers at other utilities across the nation. Operating a T&D system in an environment with high wildfire risk is a dramatic change to what we're used to. It's completely different than how we were taught and it's tough on the gut to fully implement.

The most-effective wildfire operational mitigations and cheapest to implement, are Enhanced Power Line Safety settings or fast trip settings, coupled with disabling automatic reclosing. You've got to have a PSPS program. These are the most effective tools in the toolbox.

Also important to discuss is the wildfire risk in general across the nation. At one time, wildfire risk was considered to only be a west coast thing. Trust me when I tell you that it is not. It's very important to share the lessons learned and do everything we can to encourage utilities to our east to get prepared, to start looking at this risk. To take actions now and be proactive as possible.

PUF: You have a leader in your CEO Patti Poppe. Talk about the culture of PG&E.

Mark Quinlan: I've been at PG&E for ten years now, and have worked with several leadership teams, CEOs, boards, as we went through the hard times. Patti came in 2021.

She's here to change the culture, to change hearts and minds. She's here to make it right and make it safe.

At PG&E, it's safer than it was yesterday, and it will be safer tomorrow than it is today, because of all the great work our coworkers are doing. We are going to keep pushing that objective.

Patti is big on breakthrough thinking and on the lean operating system. Breakthrough thinking is teaching us how to think differently and deliver extraordinary outcomes. The lean operating system shows us how to execute our plans with more predictability. Breakthrough thinking and the lean operating system are two of three components to our Performance Playbook.

The third leg of the stool is our safety excellence management system, PSEMS, we call it. That's our entire safety, multi-faceted plan. That's our Performance Playbook.

We run emergencies well. We can restore a big storm quickly. What we need to get better at is preventing emergencies and running the day-to-day, blue-sky business better based on learnings while in emergency mode. And the Performance Playbook is helping us do that.

That's what we're doing. I love it. We've seen some good results and have a lot of momentum. It's encouraging for those of us who have been around for a while, but we know we still have a lot of work to do. A continuous improvement mindset is front and center for all of us. PUF

Ten Commissioners Talk Infrastructure

(Cont. from p. 24)

Hopefully we've built the right transmission to get the power to where it needs to be. Wyoming, as you know, is an exporting state, and we don't necessarily want all the burdens required to serve others' loads if it means increased utility costs to us that we would not otherwise incur.

PUF: How do infrastructure needs compete with concerns about affordability?

Chair Mary Throne: They have to go hand in hand, don't they? The conversation about how we address decarbonization got off on the wrong foot years ago, and I don't know how we get it back on the right track.

I think decarbonization is a collective goal and it's unrealistic to expect specific ratepayers to shoulder the entire burden. I think it's a societal objective.

Much infrastructure growth and especially research and development, are going to require a lot of continued government intervention, whether in the form of funding for research or loan guarantees. The picture, in my mind, has been getting a little clearer over the last few years since I started this job, but I still don't see a clear path to either 2030 or 2040.

The path may become clearer in the next few years as we hopefully get better information on the commercial viability of advanced nuclear, hydrogen, and carbon capture. The next few years are going to be critical in determining how we achieve that ideal goal by 2040. Because in the utility world, 2030 is almost yesterday and 2040 is tomorrow. PUF

PUF Annual Pulse of Power Survey

(Cont. from p. 53)

among industrial, technology, and data center end-consumers, which enjoy an expanding portfolio of options and incentives to invest in clean onsite power generation across their facilities.

Bullish on Federal Investment Programs

Nearly 80% of survey respondents expressed general support for energy transition funding programs, including the Inflation Reduction Act and Build Back Better. Within this group, there was an even split between those who would like to see even more investment and those who were open to additional dollars, so long as system reliability could be maintained. Just one-fifth of respondents felt investment should be reduced and better aligned with system needs.

See Question 7.

When asked how the Inflation Reduction Act (IRA) would be remembered in twenty years, respondents saw a mainstreaming of transportation electrification and charging infrastructure (56%), expanding clean power and renewables as the largest share of generation capacity in the U.S. (56%), and accelerated T&D upgrades and improved power system reliance (48%) as the most likely scenarios.

With nearly $370 billion allocated toward building a clean energy economy under IRA, progress toward net zero (37%), jumpstarting clean hydrogen (32%), and an expansion of cybersecurity and digitalization across the energy system (30%) were also seen as likely beneficiaries, although to a lesser degree.

Meanwhile, carbon capture and sequestration (22%) and equity and energy affordability (19%) garnered the least number of votes in spite of the IRA's stated goal of accelerating climate change solutions and improving energy access across the U.S.

See Question 8.

The Ninth Annual Pulse Survey highlights that over the length of the study, many past themes remain true to this day. The power industry is consistently optimistic about transportation and building electrification opportunities but demonstrates a consistent bias in favor of grid reliability and T&D investments.

The regulatory landscape continues to play the spoiler, frustrating more ambitious energy transition initiatives. There remains widespread consensus that innovation and investment are critical to the industry's future. At the same time, the industry remains committed to balancing progress with system reliability.

What has shifted over the past decade is a significant focus on managing expanding clean, renewable, and distributed power towards resilience above all else. Given the rising tide of existential threats, this comes as no surprise for a power industry that finds itself, on one hand, awash in exciting innovation, and on the other, facing a new era of daunting operational complexity. PUF

PUF Annual Pulse of Power Survey 2024

How You Answered Eight Questions

By Guidehouse's
Mackinnon Lawrence, Nick McClusky, Bill Hughes, Joe Owens,
an analysis of the survey results.

Guidehouse's Ninth Annual Pulse Survey of utility executives in North America on the state and future of the power industry, conducted in partnership with Public Utilities Fortnightly, highlights a shift in the industry priorities away from decarbonization toward more resilience-focused investments.

Coinciding with more of a risk-mitigation focus is a willingness among U.S. utilities to lead by example and mobilize innovation in the face of mounting disruptive threats. This includes investing in a more flexible, resilient, and ultimately, more reliable power grid.

At the same time, utilities recognize the importance of balancing competing priorities and are keen to leverage partnerships with regulators as well as state and local governments to capitalize on opportunities within the energy transition. This survey was conducted from March to April 2024, with 405 executives responding.

Addressing competing priorities is a familiar challenge for utilities. Customers demand low-cost, clean, safe, and reliable power. At the same time, energy infrastructure investments require advanced planning with an eye toward a service life extending, in many cases, to 2050 and beyond. All utility initiatives must ultimately align with the endorsement of regulators – many of whom have their own vision around balancing priorities – while also taking into account rapidly shifting public opinion.

Resilience Top of Mind

A third of respondents to this year's Pulse Survey point to climate change and destructive climate-related disasters as the most disruptive existential threat to the power industry today, while slightly more (40%) cited aging infrastructure, an overall decline in the quality of life, and community livability as the most pressing concerns today.

For many communities across the U.S., these two threats go hand in hand, creating urgency for utilities to improve system reliability and deliver 24/7 power to their customers. While just a quarter of respondents cited inequity and rising costs associated with maintaining quality of service, this existential threat saw a ten-point increase from last year's survey, consistent with heightened industry focus on keeping pace with customer demand and preferences.

See Question 1.

When asked what infrastructure-of-the-future vision utilities should build in the communities they serve, more than half of respondents (57%) pointed to storm-hardened, self-healing, and resilient power delivery providing 24/7 uninterrupted power.

See Question 6.

The responses to both questions underscore the reality that each utility faces a unique mix of existential threats, and therefore, may prioritize different pathways. In all cases, growing challenges to system reliability appear to be pushing to the back burner more aspirational goals like equitable access and decarbonization.

For example, just 17% of respondents would like to see utilities prioritize a fully electrified built environment and transportation system powered by a hundred percent renewable energy in the communities they serve over improved resilience (57%) and greater customer interactivity (26%.) This is a point of departure from past surveys in which we observed a strong consensus around the urgency of decarbonization.

All utility initiatives must ultimately align with the endorsement of regulators – many of whom have their own vision around balancing priorities – while also taking into account rapidly shifting public opinion.

Flexibility Investments Take Center Stage

Improving resilience for the power industry requires integrating more flexible generation and digitalization into the system. A majority of pulse survey respondents (61%) share this view, noting that utility investments should prioritize increasing flexibility to improve energy system resilience over accelerating deployment and integration of clean and distributed energy (25%) and promoting equitable growth and beneficial impacts to customers across the network (14%).

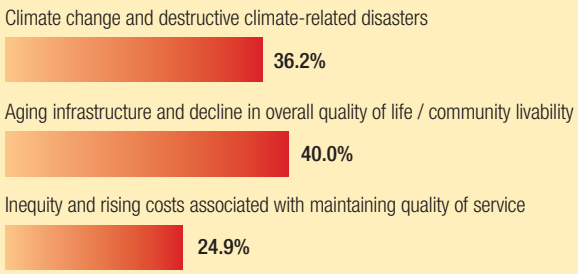
See Question 3.

Improving grid flexibility is a complicated challenge for the power industry, but expanding investments in programs that facilitate collaboration between utilities and their customers, while also leveraging DERs, demonstrate an exciting evolution in solutions that can simultaneously promote all three infrastructure investment outcomes posed to PUF readers: accelerating deployment and integration of clean and distributed energy; increasing flexibility to improve system resilience; and promoting equitable growth and beneficial impacts.

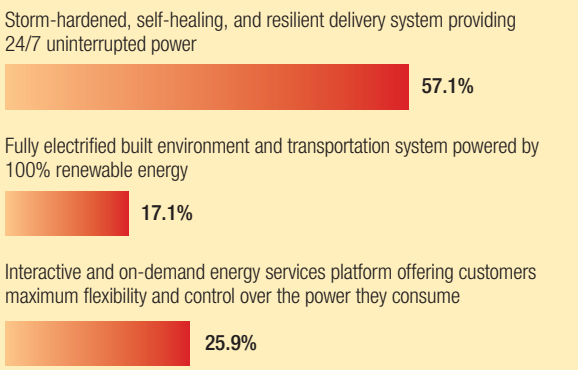
Guidehouse Insights' Energy Transition research underscores the criticality of technology innovation acting as a grid flexibility force multiplier. According to Guidehouse Insights forecasts, at least $1 billion will be invested annually in advanced distribution

RESILIENCE

Q1. What is the most disruptive threat facing US utilities and the communities they serve today?

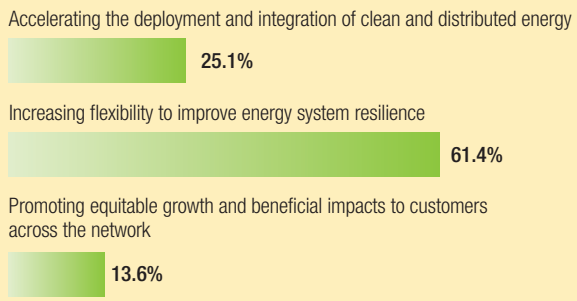


Q6. What infrastructure-of-the-future vision would you most like to see utilities build in the communities they serve?



FLEXIBILITY

Q3. Which of the following outcomes should utility infrastructure investments prioritize?



management systems by 2035 to improve grid reliability in North America.

At the same time, innovations in CE/CX technologies point to a digitally enabled flexibility transformation across the grid edge ecosystem. Investments in behavioral and structural energy efficiency technologies that interact with behind-the-meter technologies like electric vehicles represent an exciting opportunity for utilities to better tailor incentives for their clients. An estimated 90% of North American homes will be served by customer engagement and experience analytics programs by 2030, increasing from around 65% today.

As in previous years, distributed energy resources (DER) continue to attract a growing share of investment across the power industry. Guidehouse Insights analysis forecasts that revenue from DER management technologies in North America will grow to five times current levels by 2030, generating nearly half a billion in annual revenue. DER's exponential growth in recent years and associated intermittency are likely a key contributor to a renewed focus on flexibility and predictability in this year's pulse survey.

Building Regulatory Consensus

Continuing a clear theme in prior Pulse Surveys, the current regulatory landscape in the U.S. casts a long shadow over the power industry's pursuit of energy transition innovation. As in previous years, most respondents (42%) see the current utility regulatory landscape in North America as behind the times, outdated, and misaligned with today's system needs and investments.

Just under a quarter of survey respondents agreed with the notion that the regulatory landscape is too rigid and restrictive, and stifling of innovation. Just 36% of respondents see the landscape as constructive and striking a productive balance between utility investment priorities and customer demands. While some improvement over previous year's surveys, it's clear that there is still a gap between power industry ambition and regulatory appetite for aggressive innovation.

See Question 5.

Irrespective of whether the regulatory landscape is overly restrictive, misaligned with today's system needs, or just right, utilities are wrestling with whether to proactively innovate out ahead of disruptive threats or invest precious time and capital into cultivating critical partnerships. Not surprisingly, nearly all respondents (99%) rejected the notion that utilities should resist change and bury their heads in the sand in the face of disruptive threats.

See Question 2.

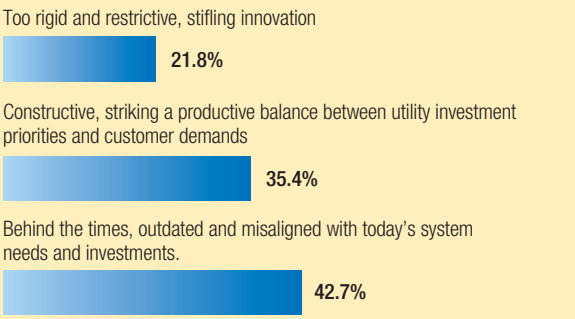
Meanwhile, most of the respondents (67%) embraced a more proactive approach in which utilities lead by example to mobilize the public sector and regulators to innovate out ahead of threats. This is an encouraging trend and shows a willingness among utilities to be out in front of looming threats to the status quo as opposed to taking a more reactive approach, a view shared by less than a quarter (22%) of survey respondents.

It is increasingly clear that in spite of a complex regulatory environment, utilities are eager to act on multiple fronts to achieve their mission of improving resilience and better serving their customers. A growing backlog of desirable projects offers demonstrable value to the grid, and ultimately, to utility customers.

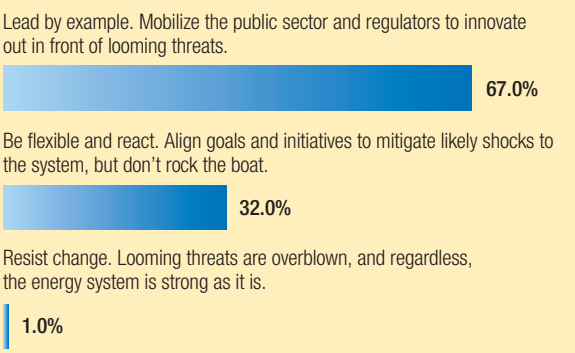
Utilities must work constructively with a variety of stakeholders

Regulation

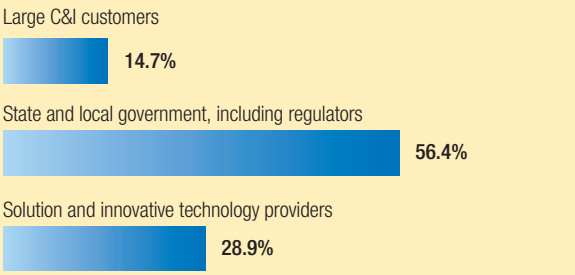
Q5. Which of the following statements best characterizes the current utility regulatory landscape?



Q2. How can utilities best serve their customers and communities in the face of disruptive threats?

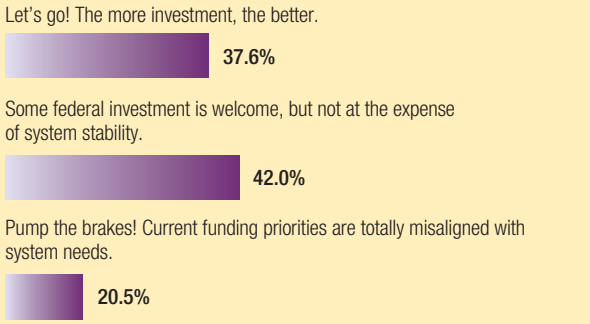


Q4. With which of the following stakeholders should utilities prioritize partnering with to successfully navigate the Energy Transition?

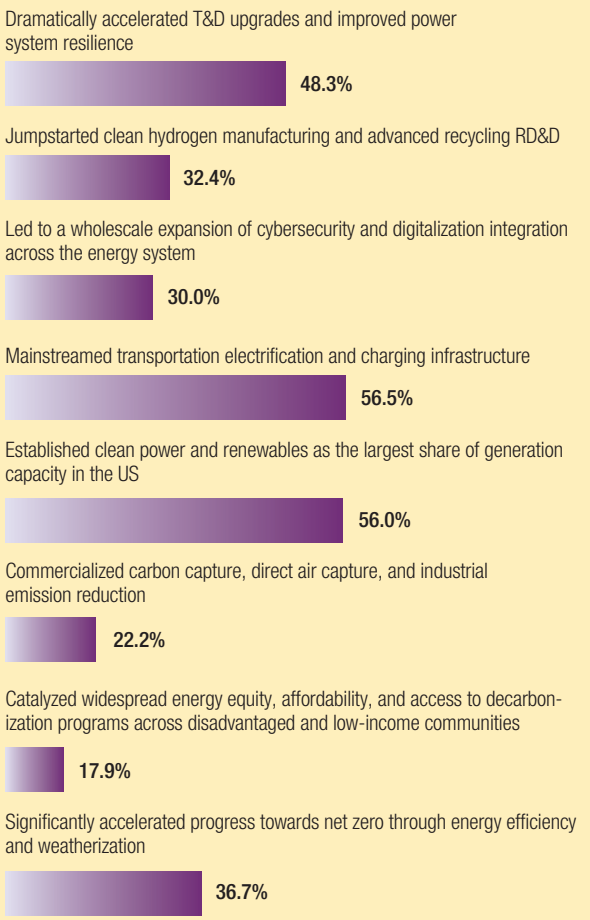


Investment

Q7. How would you describe current utility attitude towards funding support for the Energy Transition (e.g., Inflation Reduction Act and Build Back Better)?



Q8. Twenty years from now, how will the Inflation Reduction Act be remembered (select 3)?



to realize their goals. When asked which stakeholders should utilities prioritize partnering with to successfully navigate the energy transition, more than half (56%) pointed to state and local governments, including regulators.

See Question 4.

It's worth keeping an eye on whether this portends a shift in sentiment away from investing aggressively in solution and innovative technology providers (29%), which has been a clear theme in past surveys consistent with a surge of investment into emerging companies by utilities over the past decade.

Somewhat surprisingly, only 15% of respondents pointed to large commercial and industrial (C&I) customers as key partners in navigating the energy transition. This is counterintuitive given the importance of these customers to the utility bottom line, as well as their increasing focus on decarbonization. Utilities will need to remain close with these anchor C&I customers, especially

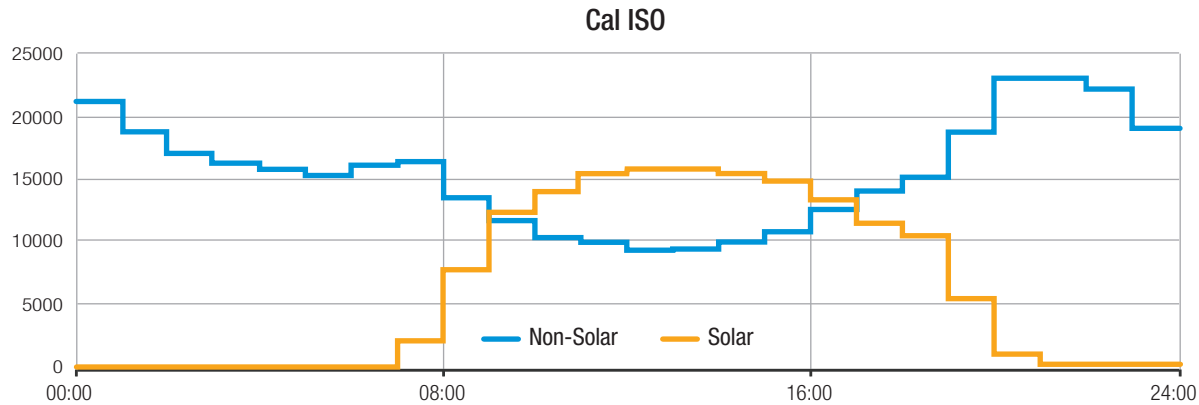
(Cont. on page 49)

A Day in the Life of the Grid

Cal ISO, PJM, ERCOT

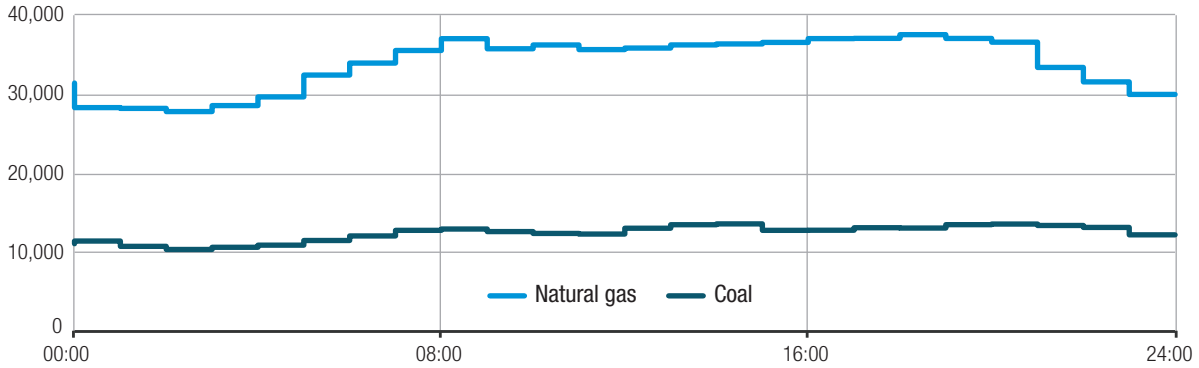
The regional power grids are changing rapidly and facing unprecedented challenges. Here's a look at one day, a month ago, the fifteenth of May, a Wednesday, illustrating interesting dynamics in three regions, those of the California ISO, PJM in the mid-Atlantic, and ERCOT in Texas.

Cal ISO, as is shown here, regularly encounters a swift decline in solar generation in the late afternoon necessitating a swift rise in a mix of non-solar generation to compensate. PJM, as is shown here, depends quite heavily on natural gas generation far more than coal generation, a reversal of the situation not long ago. ERCOT, as is shown here, experiences that same swift decline in solar generation in the late afternoon, precipitating a dramatic increase in natural gas generation especially to compensate.



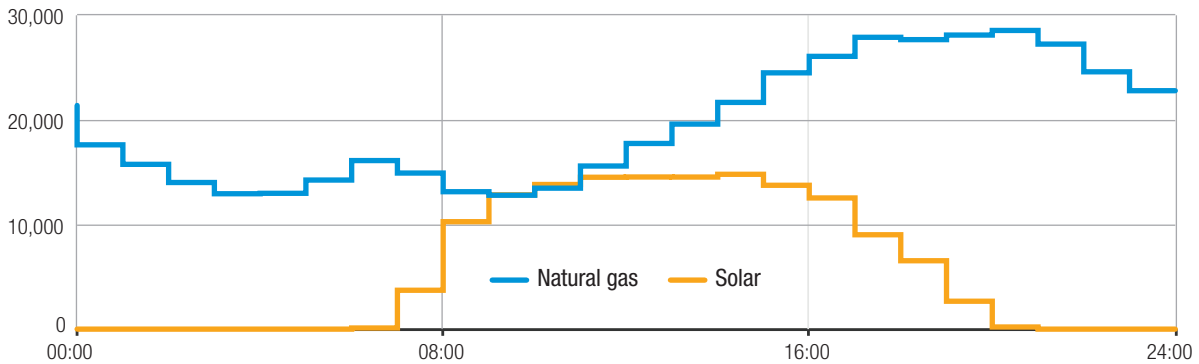
Hour ending	Total (MWh)	Solar (MWh)	Non-Solar (MWh)
12 a.m.	21,620	160	21,460
1 a.m.	19,173	169	19,004
2 a.m.	17,380	168	17,212
3 a.m.	16,679	172	16,507
4 a.m.	16,202	174	16,028
5 a.m.	15,923	170	15,753
6 a.m.	15,651	167	15,484
7 a.m.	16,423	185	16,238
8 a.m.	18,955	2,266	16,689
9 a.m.	21,800	7,986	13,814
10 a.m.	24,460	12,606	11,854
11 a.m.	24,783	14,308	10,475
12 p.m.	25,718	15,598	10,120
1 p.m.	25,447	15,985	9,462
2 p.m.	25,135	15,589	9,546
3 p.m.	25,530	15,529	10,001
4 p.m.	26,101	15,019	11,082
5 p.m.	26,225	13,507	12,718
6 p.m.	25,861	11,606	14,255
7 p.m.	25,911	10,526	15,385
8 p.m.	24,722	5,636	19,086
9 p.m.	24,442	1,070	23,372
10 p.m.	23,735	377	23,358
11 p.m.	22,744	382	22,362
12 a.m.	19,767	382	19,385

PJM



Hour ending	Natural Gas (MWh)	Coal (MWh)	Ratio Gas to Coal
12 a.m.	31,402	11,030	2.85
1 a.m.	28,287	11,371	2.49
2 a.m.	28,188	10,698	2.63
3 a.m.	27,785	10,302	2.7
4 a.m.	28,542	10,579	2.7
5 a.m.	29,644	10,848	2.73
6 a.m.	32,412	11,440	2.83
7 a.m.	33,932	12,017	2.82
8 a.m.	35,530	12,727	2.79
9 a.m.	37,025	12,894	2.87
10 a.m.	35,747	12,570	2.84
11 a.m.	36,229	12,335	2.94
12 p.m.	35,642	12,257	2.91
1 p.m.	35,836	12,995	2.76
2 p.m.	36,234	13,439	2.7
3 p.m.	36,359	13,546	2.68
4 p.m.	36,552	12,727	2.87
5 p.m.	37,035	12,740	2.91
6 p.m.	37,064	13,059	2.84
7 p.m.	37,535	13,018	2.88
8 p.m.	37,055	13,447	2.76
9 p.m.	36,582	13,525	2.7
10 p.m.	33,379	13,344	2.5
11 p.m.	31,550	13,097	2.41
12 a.m.	29,959	12,158	2.46

ERCOT



Hour ending	Solar (MWh)	Natural Gas (MWh)	Ratio Solar to Gas
12 a.m.	0	21382	0
1 a.m.	0	17618	0
2 a.m.	0	15753	0
3 a.m.	0	14016	0
4 a.m.	0	12942	0
5 a.m.	0	12984	0
6 a.m.	0	14251	0
7 a.m.	108	16113	0.01
8 a.m.	3716	14920	0.25
9 a.m.	10270	13136	0.78
10 a.m.	12839	12799	1
11 a.m.	13827	13475	1.03
12 p.m.	14518	15592	0.93
1 p.m.	14544	17748	0.82
2 p.m.	14538	19601	0.74
3 p.m.	14801	21673	0.68
4 p.m.	13751	24500	0.56
5 p.m.	12539	26076	0.48
6 p.m.	9021	27897	0.32
7 p.m.	6537	27674	0.24
8 p.m.	2667	28111	0.09
9 p.m.	204	28552	0.01
10 p.m.	0	27247	0
11 p.m.	0	24599	0
12 a.m.	0	22792	0