



ENERGY

BEYOND THE ELECTRON PODCAST

Neural Grid and the Internet of Energy

Chris Warren: It's easy to think about the transformation of the power system only in terms of solar panels and wind turbines. That's understandable. The emergence of affordable wind and solar energy are simply the most visible signs of the rapid change from a traditional hub and spoke power system to a far more distributed and connected energy environment.

But the reality is that some of the most profound changes and innovations that are emerging from this new power system aren't visible at all. The neural grid is a great example. In the past poles and wires delivered electrons one way, from large power plants to consumers. But the emerging neural grid serves as a kind of intelligent glue that connects a heterogeneous network of generation, distribution, and storage.

As just one example, the neural grid takes advantage of cloud computing and sophisticated artificial intelligence to do everything from optimizing energy flows and stabilizing assets to improving customer engagement. The neural grid, its many possibilities and the potential impact on utilities and customers will be our topic on this episode of Beyond the Electron, the Energy Cloud Podcast Series.

I'm your host, Chris Warren, and I'm pleased to be joined today by two people who have deep knowledge and unique perspectives on this topic. With us today are Mike Bianco, a managing director in Navigant's Global Energy Practice. Mike has spent 27 years in information and operational technologies and 15 years working with utilities to plan and implement technology solutions. Mike has particular expertise around the role of technology in the creation of the neural grid. His breadth of experience stretches across the technology stack, including data center design and build, network cloud architecture, server infrastructure, integration middleware, application development, data analytics, enterprise architecture, and security.

Also, with us today is Joseph Santamaria, chief information and digital officer at the New Jersey based utility PSEG. Joseph leads the utility's enterprise digital and IT initiatives, including corporate IT as well as PSEG's unique energy cloud program. This includes PSEG's digital transformation of operational and smart grid technologies, energy efficiency, digital customer and PSEG's digital product offerings.

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About Navigant

Navigant Consulting, Inc. (NYSE: NCI) is a specialized, global professional services firm that helps clients take control of their future. Navigant's professionals apply deep industry knowledge, substantive technical expertise, and an enterprising approach to help clients build, manage, and/or protect their business interests. With a focus on markets and clients facing transformational change and significant regulatory or legal pressures, the firm primarily serves clients in the healthcare, energy, and financial services industries. Across a range of advisory, consulting, outsourcing, and technology/analytics services, Navigant's practitioners bring sharp insight that pinpoints opportunities and delivers powerful results. More information about Navigant can be found at navigant.com.

We'll jump right in to our conversation now. Mike, I'll start with you. Lot so people listening will be familiar with the concept of a smart grid. Can you talk about how the neural grid is both similar and different to the smart grid?

Mike Bianco: Sure, over the last 10 to 15 years, smart grid has really come on strong with a new value realized in a variety of areas across the utility. Energy efficiency and demand side management, for example, asset management as we talk about performance health and asset performance and health monitoring, customer choice as we talk about new energy structures, new rate structures, and of course a variety of use cases and value in grid operations as we have new visibility to parts of the system we didn't previous have. These, what we might call new pockets of value, have been enabled by a combination of increased network and connectivity performance primarily.

As we talk about the new infrastructure, digital infrastructure, on the network side enabling the flow of new data. We're gonna talk a lot about data in this session. It really is about the data, getting access to the data. And that data is now coming from new digitally connected devices, like smart meters we're all familiar with, distribution centers, new automation technologies, new microprocessor based assets in the TV infrastructure, a variety of devices behind the meter in the home as well that are providing value back to the utility into the consumer.

This new digital infrastructure, these new advancements have really paved the way to new applications and analytics, and we're gonna talk a lot about analytics as well. For the benefit of the utility and the customer, and this is what we might refer to as smart grid.

Similarly, let me just move on, similarly I would say that these continued developments haven't stopped over the last five to eight years specifically in networking technologies as we've been more focused on the use of the cloud technologies. And then we bring in areas of digitization, converting and creating data in digital formats for use by computers.

And this other five dollar word we might call digitalization, the use of digital technology to create new values. We get access to the data, we have new digital assets that we're pulling data from. And this has helped the smart grid evolve into a much more powerful platform, a much more powerful network infrastructure and assets, leveraging increased connectivity through the cloud, new advancements in areas of robotics.

We'll talk about artificial intelligence, edge computing, the wealth of new sensors on the network, and again advanced analytics around prescriptive and predictive capabilities that really perform a variety of new energy and non-energy applications, [inaudible 00:05:21] a significant area of value in today's energy economy. And this is what we refer to as the neural grid.

Chris: Right, so as I hear it, it sounds like it's the concept of the smart grid, but it is also layering in the importance of data and data gathering and data use to drive benefits to both the utilities and to customers. It's almost like a smart grid plus.

Mike: That's right. That's right. You know, I'm an old network guy from way back when in copper and frame relay and TVM technologies, all of which are 20 years old now. And into new fiber-based infrastructure capabilities. MPLS, we may have heard before, a variety of new digital backbone technologies that give us higher performance, better reliability and improved scalability to again pull data from all these new digital devices. And these continued advancements, even in the cell technologies that we're all familiar with in our phone, moving from 3G to 4G to 5G. These technologies are now being used in the utility and connectivity outside of the utility to shape the new energy cloud and give us this ubiquitous nature as we call it of extended connectivity and capabilities.

And then when we bring in new advancements of connectivity around the sensors, the drones, robotics, advanced again analytics and different solutions on systems integration, it's really this nucleus of continued technology advancements that made the neural grid possible and give us the opportunity to build new applications at TriValue.

Chris: Right. Right. Joseph let's turn to you. You have a big picture perspective on the changes in terms of the functioning of the grid and the new demands placed on it. Can you talk about how much of a change the emerging neural grid is to the existing infrastructure in your utilities service territory?

Joseph Santamaria: Sure, and before that, Chris, let me thank you for the opportunity to talk about such an exciting topic, as a transformation that's going on in our industry. I like to think about it in terms of four or five transformations, forces and trends that are going on.

One is, as Mike talked about, the introduction of removable and the whole theme around sustainability, which can come in terms of energy efficiency, you know, carbon free source of energy that's nuclear, or renewables. That's something that has tremendous impact on our grid because it introduces variability. If you think about the grid of your grandparents, the grid was very predictable. There was a generation shores, there were transmission lines, there were distribution lines, and there was load, a customer, a commerce. And that was ... you know that would be in change. Day in, day out, they would have some seasonality, but for the most part it was fairly predictable.

Now you have weather patterns as you depend on renewables. You have much for variability that requires a very different instrumentation in terms of how responsive the grid has to be. So when you look at the grid that we typically talk about, it's a grid of electrons. And we need to strategies thinking about a parallel grid, which is a grid of information. It tells us at different parameters, at different points at every point of the electric grid at any given point. And then the system has to be responsive enough to manage those clouds, to manage that wind variability, manage that, you know, those changes are gonna be much more real time than anything we've seen in the past.

The other thing that's changing along these lines is the electrification of transportation. So you think of an electric vehicle is a very important load in the system. And now you're talking a lot that load moving. In the past, you didn't move your home and charge in one spot in the morning or use one spot in the morning and somewhere else in the afternoon and somewhere else in the evening. That's really what's coming with the electric vehicles and the mobility of those loads that again it goes back to a grid that is less predictable, is much more variable. It has to be instrumented in a way that we, the grid operators, get that data and we have the systems to respond and best configure the electric rate to match those customer demands.

That takes me to another topic with is customer expectations. The reality is that we in the utility world, we don't set customer expectations. They are set by other sectors, like retail, the Amazons of the world of the Capital Ones of the world. That's the expectation that customers come when they consume services. So utilities, traditionally, we've done a very poor job at knowing our customers. We know when they pay us, we know where they are, we know how much energy they use.

But we really don't know much more about them than that. So, how they think of energy. Do they care about sustainability? Do they care about reliability? Are they much more cost sensitive? We have to get much better at anticipating customer energy needs, working with them, being proactive, especially if more and more of their services, for instance electric vehicles, are related to electric grid. They're gonna be much more dependent. Today you depend on the electric grid for a number of services. In the future you're gonna depend on the electric grid for more services including transportation.

So we think that's gonna raise the engagement level of customers, and we're ill prepared to really anticipate and be a good customer service provider to the extent that one would call is the norm nowadays. So all this together, I mean, Mike talked about the concept of data. And again anticipating customer needs, what's the next, we all it the next best action for a given customer a segment of one. It all requires data. And that's where [inaudible 00:11:33] coming. So we have clearly a very reliable electric grid that transmits energy, and we need to put a parallel grid of data from the employment of new technologies. You know, Mike mentioned a few, advances sensors, two way communication networks, internal things, machine learning, and create that energy services platform that allows us to manage plan and build the grid of the future.

Chris: Right, right. So the foundational purpose of the grid remains the same and the reliability expectations are always gonna be, you know, has to be very, very high reliability. It's just that there are new dynamics that need to be accommodated, and there's a need for flexibility. So the tools that have to emerge and are emerging as part of the neural grid are what allow the reliability as well as all of these additional services and customer engagement opportunities to really flourish. To me that sounds like it's an evolution based on the circumstances swirling around the grid.

So, yeah. That's just an observation. I want to followup, basically on what PSEG is doing in terms of taking advantage and promoting the neural grid. There's the energy cloud strategy I mentioned in the intro. Can you talk a little bit about what that is and how that is a vehicle for tapping the potential of the neural grid?

Joseph: Sure so the energy cloud is our platform vision for the digital services that the utility is gonna have to offer internally and externally in the future. So, we're in the process of deploying a number of smart grid devices. And those range from AMI meters we recently filed with the [inaudible 00:13:47] commission in New York and in New Jersey. We just got approved in New York and we're working with New Jersey to get AMI approved. For all the insides, all the services that we're gonna be able to offer with that data sets that's gonna come from the quasi-real time meters, they're gonna be able to provide us data that we can leverage for internal and external, external meaning third party or customer insights that we've never been able to get before.

When you look at smart meters we're about to employ, this week an Alexa channel for our customers where they can interact, pay their bills and get a balance, report a meter read. There are a number of services through Alexa, through a mobile app. Electric vehicle charges is part of our filing. We're gonna anticipate to employ hundreds of thousands of connected thermostats in New Jersey and thousands of electrical charge. So all of these will generate a tremendous amount of data. And the energy cloud is the platform that fundamentally collects all these data and has a number of engines and capabilities to offer what we call smart operations.

So with all these insights we're gonna be much better at responding to storms, deciding how to assign jobs to crews, when to do a truck roll versus when to do a digital paying. So, we're gonna have a number of efficiencies that internally we call that, we put that under an umbrella which we refer to as smart operations.

I talked earlier about customers and the digital customer and getting insights into customers that we didn't have before. With all these data, what's the next thing they're gonna need from us? Is there a service for energy efficiency that maybe they're more willing to accept and we can work with them? They're likely to have a billing question, you know, how is the outage. So being able to chat with them in a much more personalized and targeted way by leveraging the insights that these data provides us, we call that the smart customer.

And then finally what we refer to as smart energy, which is how do we help sustainability? How do we make sure that the energy that's consumed in our service areas is clearly as you said earlier, the most reliable, the best quality, but also the lowest carbon footprint that we can have? Our CEO mentioned many times, the cleanest megawatt is the one you wanna use. So how do we get insights into where the waste is, how do we get insights into where the energy needs to come from and go to, and what the service level that allows us to minimize that carbon footprint? That's what we call smart energy.

So the energy cloud is, again, the platform. We have an architecture that has a number of software engines and databases and networks and sensors that we will build upon to offer this smart energy, smart operations, and smart customer. We also want it to be an open platform. I think the utility of the future is gonna have to be more open than in the past. We've been a relatively closed systems, because we fundamentally are kind of out for an outcome in terms of reliability that we wanna control how the grid gets operated so that we can meet those customer expectations and hopefully exceed them.

But in the future the grid is gonna be much more open so from my stand point [inaudible 00:17:24] is apply from that in the future, we wanna open to third parties with customer consent, and maybe get retailers or others to go and provide energy services. Some of them may compete with us. But if energy service at the end of the day help our customers, then we think that's better for us. And obviously I think what's best for our customers is best for us as a company as well.

So that's what the energy cloud is, an open platform that allows us to serve our communities, our customers on better operations, better energy consumption, and having better insights into their needs.

Chris: Right, right. Mike I wanna bring you back in. So do you see, in the industry, the utility industry overall, do you see this kind of platform approach that Joseph just described as being the best practice, as the way to move forward, placing the utility in a sort of platform position to take advantage of all the opportunities and drive efficiencies and try to really be a ... I mean, I'm thinking of it almost as a central, I don't know, data control, I don't know, a control center in a sense from all this activity swirling around. Is that what you see elsewhere, or are there other approaches that you think are interesting?

Mike: Well, I would offer that Joseph, what he's shared and what PSEG is doing, is very innovative. I think it's absolutely the right direction. It aligns extremely well with our own research and market shaping consultation as we talk about the utility of the future and how they need to remain relevant. Navigant has been focused the last four to five years on shaping an energy cloud set of capabilities and market focus around many of the things that Joseph had talked about. So I think we're pretty well aligned.

That's probably not by a mistake, because I know we've been working with PSEG for some time now. It is actually very exciting to hear the things that they're doing, the innovation that they are now building into their company. It's just at the front end of what will be a significant technology curve and life cycle. If utilities don't step out of the 50 year old ways of operating in generating, delivering, and serving their customers, there is opportunity to be marginalized, opportunity to continue to lose customers.

Load continues to change as distributed energy resources come on line, with the focus on renewables and the lower cost capabilities to leverage solar and wind and battery combinations now. Sustainability is a core aspect of this transformation, moving us away from the centralized generation of the past.

So the platform technologies, leveraging what we're sharing today in neural grid, it really is the foundation to build upon. It is about the data, as we've talked about, and the information that can be gleaned from the data. To be relevant behind the meter in the home around Google and Alexa, very exciting. The utility needs to move that direction, to be in the conversation, because I'll tell you what. As Joseph mentioned, Amazons of the world, Microsoft, Googles, they're all doing some very interesting things and one to go gobble up that market share. So, they've got to protect their boundaries.

Chris: Right, right. So, one thing, I'm curious, it sounds when I hear Joseph talk and then what you just described, Mike, it sounds as though as a whole, utilities are generally seeing kind of the emergence of the technologies and the intelligence that made the neural grid possible more as opportunities than as threats. Is that an accurate way to look at it? And I guess part b of that would be, is that an evolution? Was the emergence of some of these affordable technologies and capabilities once seen as a threat.

Mike: I'll be happy to take that one as well, and Joseph feel free to chime in. If you ask that question five years ago, I think you'd probably have a different response. It was kind of a head-in-the-sand response in terms of threat or opportunity. But now what we see in our research and in our interaction with clients is that utilities see it as both. They appreciate the very significant threat nature. They see the changes in their load patterns, they see the changes in their customer base, they see the new entrance into the market that are creating opportunities to generate and to lever energy outside of the utility.

And that in turn, turns them to the things that we're talking about around new platform and development that create products and services that ultimately drive those opportunities for new revenue and to stay relevant and to keep those customers, to deliver new customer choice that Joseph talked about, for example.

So, there's no question that the digital transformation is significantly disruptive. We've seen that across many, many industries over the last probably 30 plus years. Many companies have ceased to exist because they failed to innovate. They failed to change. I like to say the power system industry is kind of the last great vertical to be impacted by technology, because it's been regulated, and there hasn't been significant competition forces driving that change.

But today it's upon us. And there are options. And utilities are starting to realize that, and that's where the neural grid comes in, the energy cloud, the platforms that Joseph had talked about. As we talk about extending beyond the utility boundaries for energy flow and new products and services around smart cities. Building to grid, transportation to grid, these are things that we are focused on in the energy cloud concept that Navigant has brought to market.

The interesting part, I would say, as the neural grid evolves, really the incumbent status of utilities does not guarantee them a dominant role. There's no gimmes in this era. The unit directional value chain that once served a captive audience, a regulated audience, a regulated business in the utility model of today will be replaced. It will be replaced by two way power flows, multidirectional power flows. And the neural grid, the cloud capabilities, all these technologies that we've been talking about really extend the opportunity to capture new market participants, capture new energy customers, and innovate to a different way of moving electrons from point A to point B. So, It's an exciting time.

Chris: Right. Joseph do you have anything you wanna add?

Joseph: Yes, I would generally agree with Mike. I think it is an opportunity clearly. It's also a threat. There's two sides to the coin. Things are changing. I think there's a lot of debating inside of the utilities and how fast things are changing. We don't see the country and customers are gonna be dependent on an electric grid that is connected to wires versus off grid for a long, long time for tannicle reasons, for economic reasons, efficiency reasons. So we think digitally [inaudible 00:25:29] information that will take time, but never the less there's a transformation that will happen.

We see it already as a threat, because its very different for us. You're talking about software, you're talking about data, you're talking about networks that are data networks. We joke internally that one of the [inaudible 00:25:47] of utilities and that's a very different culture. So some of the things we're exploring and doing more with cloud partners and trying to drive faster innovation.

We launched [inaudible 00:26:02] a few years back within the technology community here at PSEG, and how do we fundamentally how ... if we're gonna be a company that innovates and competes not only in our ability to operate an electric grid, but also in our ability to manage data networks and make decisions of data in a real time bases toward the grid that we're ... and we're doing much of that today, but to the degree that is probably orders of magnitude beyond what we do today. What type of culture we need, where are the processes we need, what are the skill sets and differentiators we need.

We also ... we all saw that ... I do think, and you know Mike talked about the Googles and the Microsoft's and other companies. Obviously they are forces to consider. But I think utilities had a differentiator which is we are universal. So, we touch every home in the areas we serve. And if you think about some of the challenges with sustainability, whether it's some of the things that as a society we need to do more of, it's not gonna work if only the upper middle class and above can afford it and sign up for it. It has to be ... it's gonna have to be changes that impact just society. And there are very few companies that know how to do that at every level of customer segments, residential, commercial, industrial.

So, I think utilities where we're unique in the position in that regard, we're also unique in position that we have all the engineering skills on how to do this right. You know, there's a lot of, in terms of voltage and face, and how you manage the grid there's a lot of physics and there's a lot of science that goes into that, that utilities have. So I think we're very uniquely positioned. If we have the right mindset, we have a sense of urgency that is aligned with the speed at which some of these changes are gonna happen, I think we're in a very good position to really excel in the opportunity side of what's coming versus be caught in the threat side of what's coming.

Chris: Right, right. I wonder, a question for both of you is, whether the regulatory environment is keeping pace with this, I guess, momentum or speed of change. Is it ... I mean, I know it's certainly a case where there are utilities that are trying to play catch up a bit. Is it also true that regulators are doing the same. And either of you can take that.

Mike: I was gonna say, in our experience or my personal experience, you know, if the utility in general, specific to Joseph's comments on this transformation and the digital side of it being so new. If the utilities are one step behind because of that, the regulators are one or two steps behind the utilities. So, they're really, really challenged to put the regulatory frameworks in place that will support the investments needed to really transform the utility infrastructure to drive the resiliency and reliability we're talking about with all of this new digital technology. So, I actually think there is a lot of work to be done to change the mindset and some of the existing framework, how capital is invested and returned to the utility. Those things are continued to be looked at daily.

Joseph: Yeah. I would say that regulators' thinking is evolving. Utilities are just one of the stakeholders that regulators need to interface with and consider as these topics are discussed. Rate counselors are the one, there are different alternatives, different industry groups. So, there's a lot of perspectives they really need to consider. So, I understand why at times it may appear as slow. And the manager of the change is far reaching from rates to capital location to, ask mike said, how the utility gets reimbursed for some of the capital reimbursements that we have to make.

So, I do think though, that things are moving in the right direction. We had a number of meetings with our regulators in New Jersey and New York and talked about our vision on the energy cloud. I think it was fairly well received. They were definitely listening. They understand the advantages it has for customers how it helps us during storm, show it makes us more efficient, how it supports their goals with sustainability.

I think there is more and more realization in regulators that it's best to partner with the utility versus maybe not partnering with the utility. I think that maybe some of the earlier states try to make some of these change with the authorities aside, or maybe at times holding the utility at bay because they wanted to open up the system and it should use more choice, which I think is a very noble and a valid position. But then they realized, this transformation can be a much faster if the utilities is engaged the right way for the reasons I mentioned before. One, we're gonna be dependent on these massive engineering marvel, which is the electric grid that was built over the 20th century, and the rates we have across every home and every commerce and every industry in the areas we serve, and the engineering knowledge that's within this.

So, I think regulators are evolving and realizing, what's the right way to engage the authority versus what's the best way to go around the authority and maybe open up more choice. How can we get both things done. And I think utilities are also evolving our thinking and realizing that's the future that's coming, and also how do we need to work with regulators and others to make this possible. We have a lot of partnerships here at PSEG with third parties that offer electrical charges, solar programs, energy efficiency, and we're happy to open up more of the market and the choices that our customers have when it comes to energy services.

Chris: Right, right. It's a lot of change with the understanding that reliability still has to be maintained. So, I understand that it's a challenge both for the regulators and for the utilities who are trying to adapt to a very new environment.

Mike: Chris, is I could jump in for just a moment. I really appreciate what Joseph said about the partnership. It had me reflect on a recent project that we worked with one of your companies, PSEG Long Island. And that partnership was clearly defined at the front end of a utility 2.0, the next generation of capabilities for the Long Island utility where we supported a strategy and regulatory filing process. The development of that strategy, very specifically, the regulatory stakeholder body was actively engaged throughout the full strategy and filing development process. And what a success that was at the end of the day with the review and acceptance process. So, I really appreciate that perspective on partnering as we go forward to evolve these relationships.

Chris: Right. And it sounds like that partnership is an essential best practice. It's not gonna be ... without partners it's gonna be hard to make it all work. But that actually leads to ... I have a final question and I'd like both of you to tackle this one. Mike, why don't you go first. But it's all around the idea ... you know we've talked here about the neural grid being possible because of advances in technology largely and the ability to collect data and analyze data. But as we know, technology development does not ever remain static. I'm curious what both of you think about what the neural grid could become and what new technologies could transform it and continue to develop it. Mike when you look into your crystal ball, what do you see?

Mike: Well, as we've shared, the neural grid really is the foundational element that paves the way to these advanced energy cloud platforms, applications and communities of capabilities, exchanging information over software and new applications that drive the advancements that we've shared. So, where does neural grid go from here? I think that again it helps to shape what becomes a greater level of customer choice, as Joseph indicated. It shapes a safer and cleaner energy system, one that's more sustainable relative to renewable use in the system and how we control that use against the overall energy portfolio. It shapes new products and services, new relationships that we talked about, new partnerships between the utility and the consumer, prosumers of energy. Gives the capability of economically optimizing energy flow as we look at how to drive lower cost of energy usage, energy services from the utility perspective.

And one area we really didn't cover much but I think it's worth talking about is continued advancement in cybersecurity. Cybersecurity has got to be core component of the neural grid as we go forward. As this connectivity continues to evolve through the cloud and become much more connected, you know smart buildings, smart cities behind the meter, street lamps, street lights that are digitally connected and communication sensory data. It opens up the digital footprint for risk significantly.

So cybersecurity is another core element that really needs to continue to be evolved to keep those bad actors out and the unintended consequences of all of this wonderful technology and the growth. But ultimately, I guess I would end with, you know, again it's really just the foundational element that opens the door to a really exciting future of change in the energy ecosystem.

Chris: Great. Joseph, what do you see?

Joseph: Mike did a great job of describing what's possible in the utopian vision, if you will, of fast forwarding a number of years and assuming everything goes well, and technology evolves. We live in a world where the consumption of energy will be truly optimized. There's no doubt that ... I think there's less and less doubt. I shouldn't say there's no doubt, but there's less and less doubt that the way we generate and consume energy has to change to a more sustainable fashion.

We at PSEG, we're believers that renewables in commission with nuclear energy is what we need to invest in. We need to make sure that those two energy sources are fully leveraged with energy efficiency, as I said earlier. [inaudible 00:38:19] what is the one you're gonna use, but those three levers have to be pulled and optimized and maximized in a way that really make our energy consumption sustainable for the long, long run. That requires knowledge of data. That requires sensors, it requires an orchestration of many if not all of the energy consuming, energy sources through a degree that we don't have today.

We haven't talked about storage as well, but storage is a key component of managing the variability of some of the more or less reliable energy sources, like renewables. But fundamentally, that's the vision you would want to have. Utilities are also getting more beyond the meter. Typically, we stopped at the meter, and anything that happened inside your home that was somebody else's business. It's not something we necessarily played in. But you start to think about lap typical charges, start to think about solar panels on your rooftop, that those services are beyond the meter. So we're getting more and more, so I think it opens up a series of possibilities inside the home for some of the competitive differentiators that utility can bring, like the focus on reliability for instance. An asset management can maybe play a role in the home so there can be additional opportunities for utilities beyond the traditional ones.

And then I was also hoping Mike would not mention cybersecurity so I would be able to bring it first time, but I guess he beat me to it. You know the whole cybersecurity and privacy, because there are two dimensions to it. This all can come crumbling down very quickly if we have major events that turn this connected grid into an attack point of vulnerability for us. I think you'd see a backlash that could set this progress back many, many years if not for good.

And then obviously there is a trend more and more rightfully so towards privacy and making sure that you are the owner of your data and you're the one who decides who your data is used, by whom and when. So of course the utilities, as we build this energy cloud type of platforms, have to make sure that we don't let the time in get too far ahead of us and we have to make sure at every point we respect and we have center mind the customer rights when it comes to privacy and everything that needs to be in place to make sure these are very secure systems. Because we're gonna be more dependent on them, and they're gonna be more far reaching into our communities, into our cities as Mike alluded into our own homes. So that's something we have to keep very, very front and center as we design and build the systems.

Chris: Thanks Joseph. And thanks to you Mike as well. Well, that's all the time we have today. This has been a really good conversation. It's interesting, data and all the different mechanisms of the neural grid that we discussed today are gonna play such an important role as the energy system continues to become more distributed and decentralized. And while it's tempting to think about what that looks like physically with all the solar panels on roofs and battery chargers in garages, the entire transformation and it's ability to deliver benefits to both customers and utilities is really gonna require, as Joseph pointed out earlier, a parallel grid of information and transactions. That's gonna be really interesting to watch as this moves forward into the future. Thanks again for listening, and we hope you join us on the next episode of Beyond the Electron.