Algorithms & Power Systems Architecture:

Using Historical Analysis to Envision a Sustainable Future

Oral History Project

Interviewee: Robin Podmore

Interview Date: July 23, 2024

Place: Seattle Convention Center, Seattle, Washington

Interviewer(s): Julie Cohn, Daniel Molzahn, Sairaj Dhople, Jess Slater

Transcriber: Temi

Keywords:

Robin Podmore, University of Canterbury, John Undrill, stability analysis, Energy System Computer Applications (ESCA), Supervisory Control and Data Acquisition (SCADA), Systems Control, Electric Power Research Institute (EPRI), Power Industry Computer Applications (PICA), Smart Village, system operator training, grid simulation, North American Electric Reliability Corporation (NERC) operator certification, Anjan Bose, Bill Tinney, Neil Stanton, blackouts, rotating inertia, Cascadia, Habitat system, Distributech.

Abstract:

Robin Podmore describes his educational background in New Zealand, including attendance at the University of Canterbury in Christchurch, working with John Undrill to simulate grids using digital differential analogs. He completed a post-doc working on transient stability simulation in Canada. He discusses working at Systems Control, in California, on stability analysis, and then moving with a team to Seattle to start Energy System Computer Applications (ESCA), a company that developed SCADA systems and real-time applications. He explains that in 1990 his focus shifted to grid simulation for training system operators, using software from the Electric Power Research Institute (EPRI) and building on work done by Anjan Bose. He discusses his volunteer efforts through the IEEE Power and Energy Society Humanitarian Outreach Program, and the development of Smart Village, a project to build mini-grids in areas with limited access to electricity. This project has impacted more than 2 million people worldwide. Dr. Podmore

demonstrates mechanical analogies for aspects of power system operations and system failures. He illustrates his training approach with a map of a fictional power system. He discusses the value of scalable models for training engineers and operators. He discusses the role of inverter-based resources in grid stability. He describes synchronous condensers as an option for replacing the rotating inertia lost when coal- and gas-fired power plants are retired. He explains that batteries hold promise for smoothing out frequency waves that occur when generation is lost on the system. He talks about training individuals in Iraq and Viet Nam. He emphasizes the value of paying attention to local knowledge when working in new places. Dr. Podmore describes the use of scenarios in grid operator training and then emphasizes the value of engineers going through the operator certification program provided by the North American Electric Reliability Corporation (NERC). He talks about past blackouts and how they triggered advances in grid modeling. He discusses competition among companies working on power system stability software and collaboration with utilities and vendors to solve problems. He closes by discussing the importance of informing the public about power system technologies to help make good decisions about system infrastructure.

Note regarding Transcript and Timestamps:
Timestamps appear in the transcript but may not align with the recording. Pauses and interruptions may have been removed, and the overall length of the recording may be reduced.

Transcript:

[Interview note: this interview took place during the IEEE-PES General Meeting and Dr. Podmore refers to sessions taking place during the meeting within the interview.]

Julie Cohn (00:00:53):

This is Julie Cohn. I'm conducting an interview with Robin Podmore on Tuesday, July 23rd, 2024, at the Seattle Convention Center in Seattle, Washington. Sairaj Dhople will assist with the interview, as will Daniel Molzahn via Zoom, and Jessica Slater, who is in the room with us. Dr. Podmore, during today's interview, we're especially interested in your early work on power grid optimization and control and later simulation, and how this was carried forward into standardized practice. But we'd like to begin with some introductory questions and general background information about you. So if you would, please describe your educational experiences and your professional positions in power systems.

Robin Podmore (00:01:38):

Okay, thank you. Well, I'll start at the beginning. I grew up in a small country town in New Zealand, and sort of worked my way through school through a combination of potato farming and sheep farming. And I was fairly good with things mechanically. And so I went to— from that town to University of Canterbury in Christchurch. And my professor assigned me a job to simulate grids with digital differential analogs. He was Dr. John Andrea, and believe it or not, he was doing artificial intelligence, and he's still publishing papers at 93.

Robin Podmore (00:02:23):

He didn't know a lot about power systems, but he got some scholarships from the New Zealand Electricity Department. And I still remember being in his living room once a week or once a month, and networking with other folks that were doing amazing things. And they gave me some great guidance. But in the British system, you wander in the wilderness with hardly any guidance. After three years, Dr. John Undrill, who grew up in New Zealand, came and gave me a good kick in the butt, and actually got me on track to complete my thesis. And John, of course, was amazing. He went on to write PSSE and PSLF, and I actually still remember him writing that code back then. So back then it was punch cards and a deck.

Robin Podmore (00:03:12):

But even before that, I was working with an analog computer and a hybrid computer. So I started growing up with a lot of different computer technology. So I applied to do a postdoc in Canada. Spent 15 months there on transient stability simulation. And my wife came with me, and one of my heroes at that point was Bill Tinney, who had written some early work on sparse matrix reduction. I still remember meeting Bill as we went through Portland, and there was a— my connection with the world was the Power Apparatus and Systems Magazine. [*And the Proceedings of the Power Industry Computer Applications Conference*] It was about this thick—a brown book. And that was like the motivation for me to learn from that community. And so I did 15 months as a postdoc, 50 degrees below zero when we get there.

Robin Podmore (00:04:07):

I've made brothers and sisters and friends, closer than my own, as close as my own family, as we come to the US. So back then, it was the Power Industry Computer Application conference was every two years. So you get to know these, these folks through their publications, and then you find that when you get here, they're really helpful. So through the time in Canada, I met some people at Systems Control in California, Neil Stanton, Norris Peterson, again, they had been publishing in this area. And I took a job at Systems Control. It was the first systems company, literally, in Silicon Valley. It was a spinoff of Stanford Research, which was a spinoff off of Stanford. And then I learned about the whole system where you could apply for grant funding and got involved with EPRI and worked on coherency-based equivalents direct methods for stability analysis and built a core team for power system research.

Robin Podmore (00:05:20):

A group of us in 1979, decided to move up to Seattle and form a company called ESCA, Energy System Computer Applications. And at that point, I'd learned how to write proposals, so they put me in charge of marketing. Yeah. And so I kind of got more into the marketing business, and we grew ESCA into the world's leading energy management company. And that's when I had to learn about all the SCADA systems and the real time applications. Now, in 1990 I decided to leave ESCA and start a company to do grid simulation and train system operators. So for the last, what, 34 years, I've been in the business of doing simulation. We licensed the software from EPRI, which EPRI actually funded, and it was written at Arizona State, under the guidance of professor Anjan Bose.

Robin Podmore (00:06:23):

So, Professor Bose has been like a brother to me, really helping guide me. And now I'm coming full circle. There's, there's, there's a need to really have the very best grid simulation software, train the operators to build digital twins, to simulate what the grid can be like as we shut down the coal plants, the fossil plants, and we bring in the inverters. So I'm actually back into coding 16 hours a day. And what I really love to do is take the complexity of power systems and boil it down to simple mechanical analogies. In the US, many of our operators have come up through the ranks. They've been power plant operators; they've been substation linemen. They have really, really savvy people. But we can't be presenting lots of equations to them. We've got to make things nice and simple, and let them—give them the tools to make a real-time decision. So to me simulation is just like a big video game. It is amazing what you can do through—and now digital twins are the new rage. So there's, there's amazing opportunity.

Robin Podmore (00:07:40):

So that's a quick overview of the technical side. On the volunteer side, I was asked to be the representative IEEE Power and Energy Society on the Humanitarian Outreach Program in 2009. The past President, Wanda Reder, saw a talent that I didn't even know I had. So basically it was Ray Larson from Nuclear Plasma Sciences. Ray had the idea, let's take a trailer, put some batteries on it, put some solar panels on it, and ship it to Haiti. And since that, we have built Smart village. I believe we've impacted over 2 million people. And we are one of the main sponsors of African-born, African-educated mini grid supplies.

Robin Podmore (00:08:32):

And what I'm finding is all the big grid practice and technology is the same as the small grid technology now. I mean, there's just more panels, more batteries, and more wind turbines, and you just got to learn how to string them all together. So I tell students when you join the Power and Energy Society, you make so many friends, you get so much guidance, you literally have a chance to do things you can never dream dreamed of when you were growing up in your original village.

Julie Cohn (00:09:07):

So it sounds like although you have a PhD, your professional career has been outside of the academy. Is that true? Or have you had university appointments as well?

Robin Podmore (00:09:18):

I've never had an official university appointment. There was a stint there where Professor Bose was going back to Washington, DC for an assignment with the Department of Energy, and I actually put together a course that was online that taught power systems computer applications.

Julie Cohn (00:09:44):

Oh, okay. So would you position yourself as more in the industry, in consulting, in a research lab? It sounds like you've bridged several of those worlds.

Robin Podmore (00:10:01):

I really have to wear three different hats. When I'm here, I can get into all the detailed technical discussions. Then I'm with, when I'm with the system operators, I have to take everything and just get it down to some real simple mechanical analogies and be very conscious of setting up the scenarios. And then when I'm with the Smart Village group, I'm really trying to—you're constantly listening, to really understand. And so it is just an amazing mix. But now with all the changes and especially—what the solar and the batteries are doing is—they're making it—the technology is explainable to everybody. Whereas obviously, only a very select people can understand how a nuclear plant works, how a large thousand, a thousand-megawatt coal plant works. So that's what I love. I keep—I tell people, I—in some ways—I learn just as much or more—when you volunteer, you may think you're giving, but you're actually opening yourself up to learning so much from everybody across the world. And that's what's just amazing.

Julie Cohn (00:11:13):

That's interesting.

Sairaj Dhople (00:11:15):

Robin, I want to pick up on something you mentioned. You talked about mechanical analogies. And this may be a bit of a tangent, but can you say a little more about that?

Robin Podmore (00:11:25):

Well, that's the question I love, okay, because I actually grew up—I don't share this a lot—the way I raised money to get through college. I actually used to go to our rubbish dump and get spare bike parts and put them together and paint them up. Okay? And, my hero was, his name, Mr. Rogers. He drove the bus from where I went every morning eight miles to the high school. And my physics teacher [*Mr. Rex Miller*], I still remember, he was a great, great teacher. But he [*Mr. Rogers*] actually built a bus from scratch. Okay? He ran the local bike shop, and I used to buy parts from him, and I actually used to watch him build this bus. So, I was more mechanically inclined versus a ham-radio-type person.

Robin Podmore (00:12:13):

So, as I went through—I'll give you an example. There a thing called Lyapunov's theory where you use the lowest un[*stable*]-equilibrium point to determine is the system stable or not? Well, my analogy was stability is like a bowl, and there's saddle— [*saddle points around the rim of the bowl*] You're sitting at the bottom of this bowl, but there's a mountain pass in that direction, and there's a mountain pass in that direction. <gestures> The theory is that you use the lowest saddle point, but when you think about it, you want to use the saddle point in the direction that you're shooting the ball to go over a hill. So literally, I came up with a way of doing direct analysis of transient stability with a ball rolling in a bowl analogy. And people use that today.

Robin Podmore (00:13:05):

So that—just one example. Alright. I really love the mechanical analogies versus all the math. And that's why we got to do a better education. Right now, airplanes fly, fall out of the sky, and the public generally knows that if the angle of attack is too great or the speed is too slow, you'll—it'll stall. And so they understand that and we have those cases. They don't understand how the power system can virtually stall and collapse. And right now everyone's talking about the replacement of, the lack of, inertia. Well, we can make up all the [*Video recording pauses starting here, audio added with permission of interviewee*] inertia just with the storage in the batteries. The inertia in the past is such that in five seconds it will roll down to standstill if you turn off every prime mover. Alright, well, you can make up that energy out of batteries. What you can't make up is the two things called the synchronizing torque. The fact that all these huge machines are keeping all the other generators running in synchronism. And so literally—that's why I brought my props. I'll have you come on up.

(00:14:22):

<Pause. Robin Podmore sets up props for demonstration.>

Robin Podmore (00:15:09):

<Throughout this section Robin Podmore gives instructions to Sairaj Dhople, who is holding a wheel. These comments are included in the transcript.>

Alright. So as we know, we have three major interconnections in the US. We've got the West Coast from sort of [*video recording resumes* here] Colorado all the way west. We've got the East. We've got the Texas, and then we've got, actually, there's four, there's the Quebec area. And all those generators have to rotate in synchronism. They just cannot—the speed [*between the generators in an interconnection*] can't vary that much. And so what I do is I use this little analogy. I say that we've got all these generators—hold the actual wheel please— and the transmission lines are like bungee cords. The power flows downhill on the angle difference. So, in order to get the power flowing, say from British Columbia down to California, the generators—hold yours steady—the generators in British Columbia have to advance; they torque a little bit. And so, what happens, for the first 30 degrees? It's not too bad, but—hang on to it real tight with your hands, 180 degrees apart, please, on either side of the wheel.

Sairaj Dhople: (16:10)
Either side of the wheel?

Robin Podmore: (16:10)
Yeah, just like that.

Sairaj Dhople: (16:12)
Like that?

Robin Podmore: (16:12)
Yeah, just like that; real, real strong. Now what happens is once I get to 90 degrees, it gets stronger and stronger. And then as I get to 90 degrees, it gets weaker and weaker, and then I get to 180 and there's nothing, there's nothing holding the system together. And so that's what's happening on the grid. Those large generators are keeping all the system in sync. And as we shut them down, the grid will just go wobbly; it'll be a nightmare. And so that's the issue. And then we've got a techno-—we can have resonance. If I wobble this at a certain speed, then the whole thing can go unstable. So it's been a really behaved, nicely behaved animal, for a long time. But

now as we retire those large generators and we bring in all the renewables, which can literally respond in a millisecond, it's going to go really wobbly.

Sairaj Dhople (00:17:11):

Robin, I love this little prop. What prompted you to come up with this?

Robin Podmore (00:17:17):

There was an operator at California ISO that, that showed it to me. And so I thought this is fantastic. And I take it around the world with me. So again, there are people that are—. Yeah.

Sairaj Dhople (00:17:34):

I want to take you to one of your most again, this might be a bit of a tangent, one of your most well-cited works on dynamic equivalence. Do you have a mechanical analogy for that? And do you want to say a little bit more about that?

Robin Podmore (00:17:48):

Yeah. That, that was thinking, look, all these generators, all these generators are going to swing together. It was before I had this analogy, but the idea is that they're all swinging together. And then if I put a phase shifter in there, I could lock them all in place. That the idea of putting the phase shift in there means that they're all at somewhat a different angle. And putting the phase shift in there means that I don't disturb the power flow. So that is a—was—I'm always looking at the swing curves and I'm thinking of what's happening physically. So that was a nice insight. Now what I've figured out is that we want to come up with equivalents. Can I just get another map?

Julie Cohn (00:18:39):

Yeah, of course.

(00:18:40):

<Robin Podmore retrieves a map.>

Robin Podmore (00:18:43):

And I just love looking at a map. Well, so I will literally spend hours just looking at the map of the whole United States or, well, the Western United States. And we have a customer in Burbank, 300 megawatts, and I'm modeling the whole United States of 20,000 buses to model Burbank. And people are saying, Robin, why do you have to do that? They've been really good at training. One thing is that they serve the power for NBC studios, so that they didn't want to have the Tonight Show on and have Jay Leno say, “our supplier just lost power.” So they've been very, very, very forward thinking. And so the issue is they get mega var support from the surrounding areas, and they're on the tail end of both the DC tie and the intermountain tie.

Robin Podmore (00:19:41):

And so I keep looking at this and I keep saying, how can I build a model that's like a scalable equivalent? It keeps the backbone. And the problem with the coherency method is, as you do the reduction, you, you get this tremendous mesh of artificial lines going from one location to another. Drives the operators nuts. Because what is this? You've got an artificial, you've got all these artificial lines just going all over the place. So the idea is to have a, the best, a scalable equivalent, where we take all these underlying lower voltage circuits and just look—equivalence them down to some sort of main trunk equivalent, and clearly show that to the operator. And just recently, I've shown that I can get a 15-to-one reduction on the size of the model. And if we look at the total United States system, it's about 100,000 lines.

Robin Podmore (00:20:36):

And the idea is I can get a 15-to-one reduction. And then the idea is, it will be like Google Earth, you'll be able to zoom out, have a scalable equivalent of the whole system, and then zoom in and start looking at—keep the scalable equivalent—and then zoom in and look at all the details of individual feeders if you want. And then of course, as you're zooming out, you're going to have to build aggregated effect of every electric vehicle, every solar panel that's behind the meter. You'll literally be aggregating, I don't know, was it 300 million? Yeah. America has like two cars for every person or something, isn't it? <Laugh>, it's crazy. And they're saying that you'll be able to run your grid, you'll be able to run—it won't be too long where you'll be able to keep—a whole city will be able to keep going based upon the vehicles that are parked in the garages and on the street. The numbers are right there. Because your typical home may take five kilowatts total, and you've got a hundred kilowatt-hour, a hundred-kilowatt battery in your driveway. It's 20 times the capacity. And think what would happen if someone inadvertently turned all those things on to discharge into, charge into the grid or the other way, it could—it'd be catastrophic. So, the need to simulate stuff and make mistakes with simulations is really, really important.

Julie Cohn ([00:22:14]()):

During your first 10, 20 years in the industry, was there one technical challenge that really stands out as especially important or thorny?

Robin Podmore ([00:22:35]()):

In a lot of ways, we've been taking a proven engine, and I've had some other folks that—a partner company I deal with it at Power Data—who've been really amazing at making sure that when we are doing a grid simulation and we have a hundred logged-on users, that it keeps on running no matter what's happening with the internet. And that, I was very blessed to have some partners that just took care of that issue. It's no small feat to literally have a model with a million values being updated a second, and someone opens a transmission line. You want every user across the whole interconnection. We used to get people all together in one big room, a big ballroom, but now we do it on the web. So that is the guy that wrote that, Mark Robinson has—did a fantastic job with that.

Robin Podmore ([00:23:40]()):

He calls it a live data message bus. And then it's more: the challenges about building a team. Obviously, I've been very honored to have the awards, the publicity, but you've always got people that are doing lots of the work behind the scenes to make things run. And so really just, I've got two a couple, Aida and Chris Mosier. And so how do you, how do you keep a team together when you've got tremendous competition from Amazon, Microsoft and the utilities are hiring like crazy now. So just keeping a team together is always a challenge. And learning how to be a leader and also be—they don't teach you about teamwork, anger management, stress and all that when you go through engineering school. So I didn't play team sports; I played tennis and squash, so I've loved the whole American—well, what happened was my son, who's just turned 42, he ended up going to the Naval Academy, flying Cobra Jets, and now flies helicopters for the Coast Guard. So I would job shadow him. And really learn about the whole thing that you have to do to build a team.

Julie Cohn (00:25:10):

Wow. But presumably you were building and leading teams in the '80s and '90s. What kinds of, what were the technical problems your teams tackled during those decades?

Robin Podmore (00:25:23):

So, in the '80s well, it was the late '75. Yeah. So '74 to '80, I was leading a research group at Systems Control, doing work for EPRI and Department of Energy. So and then as we, when we formed ESCA, the issue is when you're in—we were selling some very large systems, so it's a matter of getting everyone every—when you're selling large systems, it's a matter of getting everyone on board to put a proposal together and then not overcommit. And that, that's a real big challenge.

Julie Cohn (00:26:15):

Dan, I'm guessing you have some questions already.

Daniel Molzahn (00:26:19):

Yeah, I do have. You, you mentioned quite a few things that I found quite interesting. Maybe the first question I have is: I really like this mechanical analogy you're using here; I might use that with my students. That sounds fantastic. But I guess my question with that is how—so as we do retire more and more of these large fossil plants, do you see these, the ability to do those sort of mechanical analogies? Is that something you think will be able to continue into the future or the system just get so complex that we won't be able to come up with simplifying analogies like this that are meaningful? Or is there always going to be some simplifying analogy that we have to design the system in a way that there is some simplifying analogy that works?

Robin Podmore (00:27:06):

Great question. So the issue is, right now everyone is really figuring out, you have grid-forming inverters or grid-following inverters. And so right now, at least in the US, the grid-following of those, like to see a nice strong rotating signal. And if that signal goes wobbly, you can have the phase lock, it's the phase lock loop algorithm can actually trip the unit offline. And there's, but there's no need, there's no need to do that. So the idea is that what's happening now is that people are not explaining, there's a communications gap between the industry, the manufacturers, the people who actually operate the system. There's one case where, for a large rotating steam unit, we have a curve that—it's a frequency bound curve. You don't want that unit to operate for more than say five minutes at plus or minus two hertz.

Robin Podmore (00:28:18):

Is that what it is? And so there's, for a rotating unit, there's a non-trip zone and a trip zone. Well, unfortunately, the solar manufacturers looked at that curve and they thought, we've got to trip our plants off. But no, you don't—the—your solar plants—that curve is designed to stop the blades on the low-pressure turbine from vibrating and shattering. Okay? And literally you get to a speed where those blades start wobbling and the whole thing separates like a giant Frisbee and goes through the turbine wall. And I've got cases of that. We don't share enough now with our students the physical catastrophes that can happen. So that's a simple communication issue. And that's why what we are doing with our, with our simulations, we may bring 50 operators together, I'm saying, please, we need to bring in the people from the other, other areas that where we have to dependencies, gas, water, politicians and really get the basics of what's going on in the grid across to everyone.

Robin Podmore (00:29:29):

Because we're either going to have to keep the coal units around for longer, or we're going to have to turn them into what giant, what's called a synchronous condenser. You literally sever the prime mover shaft or maybe even leave the shaft there and you just rotate that thing. To provide that rotating inertia, but it doesn't generate any electricity. Or we actually come up with the, we can now have grid-forming inverters where that solar plant by itself—. So the thing right now, a solar plant by itself can't just start up and give you a strong signal. But you just have to change the electronics. There's hardly any change in the hardware. You change the electronics where it can actually—and of course you don't even—you just turn it on. And it will give you a nice synchronizing signal like this, alright?

Robin Podmore (00:30:25):

But again—and I learned all about this from my friend Jude Numfur in Cameroon. He's a totally self-taught entrepreneur in Cameroon that has been dealing with grid-forming inverters for a decade. Whereas in the US, you know, in Africa, you—there is no grid. So you grid-following inverters don't work. So in the US though, we're—that's what I'm so impressed is that every quarter, every fifth session here right now is about the importance of grid-forming inverters. But we've got to get that out to the public. The general impression on the public is you don't ever use any of your renewables, your wind, your solar, until you've got all your big units up and spinning. And that's because people have not been thinking of them as the need to have grid-forming.

Daniel Molzahn (00:31:19):

So maybe to follow up on that, is there an analogy for—like a mechanical analogy similar to what you were describing that. If you were describing this to operators is there a—?

Robin Podmore (00:31:28):

Here's the thing about—that grid-forming inverter can be programmed to give you a nice smooth signal like this, all right, on a synchronous machine, that signal has to be really smooth like this. <gestures> Because you've got a huge amount of inertia, literally, it can't jump like that. But with a grid-forming inverter, it's gone around like this, but just with a little bit of software, it can jump anywhere you want. So that's the mechanical analogy—is that it's a synthetic waveform. There is no rotating mass behind it. It's just a little bit of software that is telling it to be at this angle or this angle or this angle. And the fact that you could actually jump it is really, well, the fact that a bug could jump it, like we see from the CloudStrike, it's a really scary scenario. Yeah, and I won't get too much into it, but I'm actually getting into malicious scenarios. Where people actually do some bad things with this type of technology that we have to be very concerned about.

Robin Podmore (00:32:40):

So the idea is that we actually start, we go through this transition where we actually use all the inverter-based devices to emulate the rotating mass of synchronous machines. It is a really good step. And maybe that's where we'll end up in a lot of ways. Because the whole idea that we've built the world's largest machine and—Julie, is Nate your grandfather?

Julie Cohn (00:33:19):

My father.

Robin Podmore (00:33:20):

Your father, amazing. So the fact that we've got the primary control of all the governors, and we'll need to build the governing control in, but here's what's fascinating: We've built the interconnection to be so large that if we lose, say 3000 megawatt, lose the three Palo Verde units in Arizona, the frequency wave drops. Literally there's a frequency wave that the units around the ones that tripped offline will drop.

Robin Podmore (00:33:53):

And then they—it's actually with an analogy. Let’s say that I've got three generators, look, three generators all pushing a bunch of power into the system, and I lose one. What happens is those neighboring generators will put out a lot more power, they will slow down, and there will be a wave that propagates through the entire interconnection in about half a second. Where every generator across the Western interconnection will slow down within about half a second, and then their governors will respond. Now, what's, we don't have to do that. We've got, with our batteries, we have enough resources to literally balance the system out within a millisecond to compensate for that generator that was just tripped offline. And we could actually have a grid with almost, like, perfect frequency. So there's some things that—and then you could be connecting grids together through—because you wouldn't have all the—so there's some possibilities to really do the balancing locally. And so yeah, the—Nate's AGC algorithm, the principles will still apply, but we can do the balancing a lot more locally and faster.

Jess Slater (00:35:17):

It seems like you've had a lot of experiences over the world and with different types of people. You spoke about your mentors and collaborators you've had. So I'm curious, do you have any examples of how ideas from an untraditional, disciplined approach influenced your approach to solving any technical problems within the power systems you were working with?

Jess Slater (00:35:40):

And no worries if not, just, I was curious if—

Robin Podmore (00:35:41):

One of my most amazing assignments was to go to Baghdad and train the Iraqis on how to stabilize their grid. And my son was over there in the Marine Corps at the time, and my wife said, yeah, you can go. So it was amazing to actually go there and see there was a Mr. Samir in our class. He was Sunni. The others were Shiite. I was just in touch with him, and everyone respected each other. But it was sad to hear the stories when a helicopter flying over the children—but there was a—what was amazing, there was a passion. They all wanted to come to America. There was a passion for America, even though they were going through such strife.

Robin Podmore (00:36:44):

And over time, we built them up from what, 3,000 megawatts, where the only places that had electricity were Baghdad and Tikrit, to 15,000 megawatts. And every Iraqi had two TV sets and a refrigerator. And so that to me was just an amazing experience to, and now we're seeing US Energy Association sponsor me to go to Hanoi for a week and then to Nanping to see how the US is using its expertise and funding throughout the world to try and have an impact. And it is a real honor to be part of that. And then we, IEEE Smart Village, we've been having meetings every year. We have a meeting in Africa, and we bring all our entrepreneurs together and—to just see the comradery that is built from that and how we celebrate and mourn each other's losses. The ability to film, to look at what IEEE is doing is just incredible. Because the fact that we are a multi-faith, multi-nation, multicolor, just an organization, and we just have engineers sit down and work on stuff—it's beautiful.

Julie Cohn (00:38:21):

Are there moments when the cultural experiences from say, Hanoi, or a village somewhere in Africa, feed back into how you approach a problem?

Robin Podmore (00:38:45):

Yeah, we have to be lifelong learners. I have a former Master Chief in the Navy that runs our power for breadths program. He literally—he started in food service and rose to be in charge of the logistics for the entire Atlantic fleet. His name is Dave Miranda. He says, Robin, God gave you two ears and one mouth for a reason. So like, he just—as engineers, we love to talk, talk, talk about stuff, but slowing down and really listening. And there's a cultural—in New Zealand, I still remember being teased for being part Chinese several times. And so I would always be hesitant to talk about what was happening with my Chinese background. But then I learned that I got a lot of my entrepreneurial skills from my Chinese uncles. And I love it in America. I was just at a Rotary meeting in Silicon Valley. And there were kids there doing traditional Chinese dances, Indian dances and songs, and really proud of it. And I'm seeing right now—is that it is so good. Where people are able to celebrate the languages and the faith and where they came from. And that's what I'm always encouraging people.

Robin Podmore (00:40:21):

And there's a saying in the British system, don't be the tall poppy, because the tall poppy gets cut down. And so we tend to see a lot of people from all—I'm always encouraging them, speak up, tell your story. Because in America we don't have a tall poppy syndrome.

Jess Slater (00:40:43):

Dan, do you have any questions?

Daniel Molzahn (00:40:48):

Sorry, Jess, you said, you said for me?

Jess Slater (00:40:49):

Yes.

Daniel Molzahn (00:40:51):

Okay. Sorry. Cut off for one second.

Jess Slater (00:40:52):

No worries.

Daniel Molzahn (00:40:53):

Yeah, no, I have, I've got a bunch of questions. One question, a kind of follow up on and maybe a bit on what I was asking before. When you're working with the operators, you're in the control room and trying to get technologies into that space. You mentioned the importance of simple mechanical analogies. But kind of more generally, when you are trying to decide what is a good metric or what is a good methodology to—sort of good information to present to the operators, what's the thought process or what's the criteria that you use to judge? There's all sorts of stability metrics and analysis approaches and different methods that could be useful for the operators. What makes it so that some of them get in the control room and are useful and others sit in a paper and are not used?

Robin Podmore (00:41:46):

When we train operators, we always do—we get the feedback. And I remember going to Wisconsin, I was kind of tired, and the end of the day someone said, “look, Jackie”—who was a Navy nuke, says, “Jackie did a great job. Robin should have stayed home.” And it was like, oh my God. So, the—Jackie gave me one good rule. She says, "Robin, just tell 'em what they need to know to get through the next scenario, because you do—” We like to have a class where there's about two hours of lecture and then about six hours of simulation. And as engineers, we will talk about something. That's the thing about this conference. We will talk about the theory, we will talk about everything, but that's my rule is: tell 'em what they need to know to get through the next scenario.

Robin Podmore (00:42:39):

Because it's all about letting them put that into practice. And that's the rule of thumb that we've really learned. And so, in some ways, they're going through the scenario and we're sitting there, and they don't want us talking. They really want to be left alone to figure out the scenarios. And so what we've done is we've come up with a hypothetical system. It's called Cascadia, because it is layered on the state of Washington on a real geography. But the power system is all made up. So I'm not compromising anybody's proprietary data. And I learned about a fantastic theory from a Professor Nonaka, out of— studied in Japan. He's now at Berkeley. It's called the SECI

Model, socialized, externalized, combined, internalized. I've had to find good training methodologies.

Robin Podmore (00:43:42):

So we have all this implicit knowledge that's not documented. You go into a professor's room, and he'll have rooms full of books. You go into a manager of operations, and he'll have like the NERC standards and some operating procedures. So the idea is how do we get all that documented? In the past, there would be a guy called “Joe” with lots of experience, and the new operators would follow Joe around for several years. And that implicit knowledge would rub off. What professor Nonaka said is make it external. Write, write the—and that's the beautiful—of a simulator. You literally write all the scenarios down and you make the knowledge explicit. It means it can be replicated, and then you have to go, you have to combine it. It's no good if that knowledge is specific to every company.

Robin Podmore (00:44:30):

And that's the beauty of this. This is like a Rosetta Stone. We can take real things that have happened in the real world and put them on this system and have poetic license. I'm not criticizing someone for an actual event. And that's—combine it. And then the last thing is, as they, as your students practice with that, they internalize it and they build up their own implicit knowledge. And so I've had a chance. The people who do the training for the grid and the grid operators, it's a pretty amazing system. I mean, we've got NERC standards, we have to have learning objectives. We have to get certified. We've got to go through audits. And so it's a really great process that requires a lot of discipline.

Julie Cohn (00:45:16):

Who certifies you?

Robin Podmore (00:45:18):

It's amazing. You go on down to a test, NERC certifies you. You get your NERC certification. But the way you get it is you go down to a testing center and take a question, a quiz with 125 short multiple-choice questions, and you get your certification to run the grid. And I'm promoting this, I'm telling people, you should become a grid operator early in your career. Those questions are brilliant. They're not just about early days that are more about recall of the standards. Now they're asking you a question to say, they'll give you a little picture of a power system, a generator, a load, and they'll say, "You are the Reliability Coordinator. What decision would you make if you've got this kind of situation?"

Robin Podmore (00:46:00):

And then they keep changing the test. To keep up with the new technology and people. And so it's—we're very proud of that whole program.

Jess Slater (00:46:11):

You mentioned that people within should become grid operators in their early careers. In general, what advice would you have for engineers to adapt to the evolving economic landscape in the power industry? Or just advice in general?

Robin Podmore (00:46:33):

I'm so biased. I—starting all over, I would do a three-year degree in power, and then I would get a job as a grid operator, make some really good money, and then start a business on the side. Because you work shifts and you'll get like a total of 14 days a month off. Now, you've got to adapt, you've got to rest. But most grid operators have a job on the side. And the idea is that when you turn the shift over, you don't take any work home with you. The boss doesn't give you things to do. So there's—and you get to run the world's most powerful, most complicated power system, and you get paid to study about all the renewables. It's an incredible job. So—

Julie Cohn (00:47:24):

So is being a grid operator analogous to being a goalie in a soccer game, like most of the time you have nothing to do until—

Robin Podmore (00:47:35):

Yes.

Julie Cohn (00:47:35):

Everything is on you.

Robin Podmore (00:47:37):

There's a saying that it is 99% boredom and 1% sheer terror.

Julie Cohn (00:47:42):

Yeah.

Robin Podmore (00:47:43):

But the really good ones stay busy analyzing what-ifs during that time. But it really is—that's an analogy.

Julie Cohn (00:47:55):

How close is the modeling of what could happen to what is happening in real time in like, both in terms of—who's looking at the model? Is the grid operator nowadays looking at the model at the same time that they're looking at the real grid?

Robin Podmore (00:48:19):

They, let's see. When we had the blackout, the south, every time we have a big blackout there, there's more requirements to do better grid modeling. The 2011 one, prior to that, they came up with the idea of Reliability Coordinators, there's about 18 of them throughout North America, and they're responsible for managing the contingencies that can cause a cascading outage. So there's a—they actually came up with a special name for it: interconnected reliability operating limit. And those are the—the grid is so huge and complex. We can't push it to the limits. We have to be able to survive any single contingency or any probable double contingency. So that's the way it's set up. All the transmission operators that report to that Reliability Coordinator, for example CAISO is now the Reliability Coordinator for most of the Western United States. They have to follow the directions of the Reliability Coordinator. But the Reliability Coordinator doesn't mandate. They'll have a conference call, and they'll have a discussion about what's a good way to mitigate those contingencies.

Robin Podmore (00:49:49):

So we are great for N-one, N-two contingencies. But think about it. Now, you can have a fire storm going 20 miles under three separate 500 KV transmission right-of-ways. So even mother nature—it's very viable that we've got systemic things happening where you—you could have three 500 KV lines, and that's not even thinking about a terrorist taking a dozen lines out of service. And that's what we're not—we're not preparing for that as well as we should.

Jess Slater (00:50:29):

Dan, do you have any questions?

Daniel Molzahn (00:50:33):

Yeah. So I've got what, at least I've got some larger ones. One quick follow up though, on this Cascadia test case, in the exam for the operators that you had mentioned is that information all publicly available? Can we get access to old exams or to this test case and quiz our students on—?

Robin Podmore (00:50:52):

Yes, yes, and yes. The—it—in some ways it is probably one of the best kept secrets, that you can get such a good job. By going and taking a three-hour test.

Daniel Molzahn (00:51:10):

So is that—are like the old tests available? We can—are they online or are they—?

Robin Podmore (00:51:16):

Yeah. So all we ask you, all the—there's a whole bank of questions that we can get out there. The vendors in the past have typically taught to the test, but we can get you a whole bank of questions where you can see the kind of things that they ask. I'd be happy to—

Daniel Molzahn (00:51:32):

I suspect my students would find that incredibly fascinating. So—

Robin Podmore (00:51:35):

No, I'd love to my follow up. I didn't expect this, sorry, to be giving a sales pitch, but I would love to get you—. And then we've got a friends-and-family thing where we'll say: “Well, we have a thing that I either give it away,” or we say, “You don't pay us till you actually get a job as a NERC operator,” or something. There's all sorts of possibilities. But no, I'd like to follow up and even give your students access to the course—really. My goals—we're very—we're starting to get veterans certified that have no electrical background. Really. The guys who are the Navy nukes were no-brainers; they had even run shipboard systems. But I'm very proud to say now we got a person that was a weather forecaster for the Air Force. So the idea, people are looking, you've got to have the right skill sets, you've got to be able to get along with people, you got to be able to take charge, communicate. But again, there's a lot of ability to train people to do that.

Daniel Molzahn (00:52:40):

Alright, I'll follow up with you. I'm sure my students would find it really fascinating. Yeah, they would. I—at least if I—if it's my turn to ask a question, I've got another question for you.

Julie Cohn (00:52:51):

Jess, did you want to follow up? One moment, Dan.

Daniel Molzahn (00:52:54):

You had seen John Undrill writing code. At the very beginning of our conversation you had mentioned John Undrill writing code for PSSC and PSLF and you said you talked with Anjan Bose quite a bit, and with the operator simulator tools that he was using. So I'm just curious if you can kind of take us back to those settings or those situations and what was it like when these first codes were being developed and—I'm sure it was very exciting that this was really new technology being developed and deployed for the first time. Kind of what was it like being in that environment?

Robin Podmore (00:53:40):

When we started ESCA, it was challenging because there was a Catch-22. You had to have three systems installed running to pre-qualify to bid for a new system. Alright, so how do you get in the door? Well, we were fortunate we'd had the big blackout in '77. There was a meeting in '78 at the ConEd control center, and I presented the idea of a 500-bus model running on a VAX computer. The VAX was like one MIP of power. And so we decided to sell our houses in California, and we raised close to $700,000 and came up north and invested in the Habitat system, which is still in the ESCA system today. I didn't even know what Habitat was. I trusted the other people that I was joining. Okay? That they knew what they were doing.

Robin Podmore (00:54:37):

And so that, that was exciting. And then being to the point where my mentor, Neil Stanton, actually got a contract with Gulf States Utilities. And we had an advantage because the main competition was Control Data. And we had VAX computers that had DECnet, which could all work together. And so for us to win that $10 million contract was pretty outstanding. And Neil was amazing. He would actually let the customer know where our weaknesses were and the customer would actually tell him: “well, we—you can cover that.” So the idea of being totally upfront with your customers, he kind of laid that groundwork. And so over a period of time, I learned those skills. In May of '84, we got a $30 million contract with Pennsylvania Power and Light, which was like one of the biggest. I had to get every key employer at ESCA to agree to go work for Pennsylvania Power and Light if we went bankrupt. So that, I'm always about finding innovative ways—. But that was a time where what I call “kamikaze bids”—vendors were bidding on jobs at crazy prices, Okay. And losing a lot of money. But we'd all come to IEEE and sit around the table and the different vendors, the Siemens, the ABBs and the customers would kind of share about what they were doing with their projects. So that was a real fun time.

Daniel Molzahn (00:56:23):

So there was, it sounds like quite a lot of openness, even among competing organizations. Was that carried on? Like was that something that's, I mean, among the utility companies, we hear lots of stories about utilities working together. There's a lot of value in having a reliable neighbor. From what you're suggesting, if I'm understanding correctly, is that there was also a quite a bit of camaraderie among the different vendors and software companies. Is that, is that the right interpretation?

Robin Podmore (00:56:55):

There were three of the vendors had a common core. Control Data was the prime contractor for a job in Wisconsin. And System Control wrote the software. And then, when a group of 12 of us left Systems Control, we built a similar set of applications with Habitat. But there were, obviously, in those days, there weren't suits going on. But I would—it was intense in terms of the competition, but through IEEE, we would kind of meet and respectfully co-exhibit and have technical conversation. So the idea is— but there was a lot at stake. But it's nice to actually—and then what happened is we had the whole common information model where EPRI and IEC got all the vendors together to get a standard put in place. So that's the beautiful thing about—and it's a matter of how do you maintain, whatever, jovial relations? Well, it's very competitive because there's a lot at stake, but at the same time, we maintain our professional associations. Yeah.

Daniel Molzahn (00:58:25):

And maybe one other quick follow up on this, because I, so we've talked with the Anjan Bose about this a little bit before, and you had mentioned the PICA conference and you've mentioned PICA as one that it sounds like was, was quite valuable. And I know PICA sort of went away at some point and I'm curious what's your perspective on—was that the venue that these discussions were happening at and if so, was there a loss when it went away, and what was going on in that direction?

Robin Podmore (00:58:59):

Yeah, good point. There certainly was a loss when, when you think about it, but then what we've also seen is the user groups for those vendors started to become very strong. And so in some ways I think that the utility people decided, well, we'll go to one or the other. But I think—and then what we saw was Distributech really took off. And in some ways IEEE, yeah. In terms of the computer applications, Distributech became the go-to place for computer applications at a massive scale. And then the T and D show is still strong, but it doesn't have the focus on the computer applications.

Daniel Molzahn (01:00:00):

Got it.

Robin Podmore (01:00:02):

And now as I go to the various technical working groups, it used to be that there were very strong technical working groups where the vendors and the implementers would really be dominant. So we've kind of lost that right now. I'm not seeing the same intensity of expertise sharing at IEEE on system operating practices. And then we have other groups like EPRI and NERC and the North American Transmission Forum sort of filling in that whole space, where IEEE pretty much was the only player in that whole space back then.

Daniel Molzahn (01:00:44):

Interesting. Do you have any insights as to why the changes happened over time?

Robin Podmore (01:00:57):

IEEE got very, the Power and Energy Society got very theoretical for a while. Now we're starting to see much better industry outreach.

Daniel Molzahn (01:01:10):

Interesting. That’s good to hear. Very interesting.

Jess Slater (01:01:16):

Why do you think there was a gap between, like, this theoretical and then versus applicability? Because that's been an ongoing theme that we've been seeing throughout the interviews. I'm just curious if you have any thoughts towards why that was going on or if you've seen a difference in how that difference, and I can rephrase that, if they did.

Robin Podmore (01:01:41):

We've seen a huge amount of funding go into the government labs and the universities, and there's a lot of papers here published. And at the same time, we're seeing vendors maybe being more established. In the early days, if we want a new job, say it was a simulator job or an EMS job, our way to get the word out was to go to IEEE and go to those committees, and tell all the customers that we want to—everyone went there and was very proudly announcing the new types of projects they had gotten. And there was a lot of innovation in the applications back then. When you think about state estimator, optimal power flows, those things were all very new. And then there were leading utilities like the ComEds, the Dukes, the Ontario Hydros, the BPAs, they brought a lot to the table. So there was just a sense that, if you're in the EMS business, the PICA Conference and the Power and Energy Society meetings were the place to go to see what the competition was and to put your—the word out to the other industry leading utilities.

Julie Cohn (01:03:10):

And what timeframe would you give that? What years?

Robin Podmore (01:03:15):

That was happening all from the '70s to through the let's see, the '80s, I believe. Yeah.

Jess Slater (01:03:31):

And what topics do you think should be, because obviously you've been talking about the importance of these committees, these conferences. What do you think are topics that should be talked about now and in the future? Or what things do you think that are not being talked about that are—

Robin Podmore (01:03:50):

Oh, it's all there. Right now we are seeing all the topics from the grid-forming inverters, the digital twins. But that's a really good question. No, but like I was saying as I went through, well, the whole issue of the human performance. When I go to a NERC conference, it is very interesting. Because I know that the North American Transmission Forum is not open to vendors, but they talk about human performance, real-time decision making, a lot of really, really practical things: shift work, shift turnover. So it's a—I think we've got the—and that's why I'm fascinated to build a model of the entire continental United States that can be openly published and just put it out there. We're getting to a point; we could even have a hackathon. A hackathon is not just writing code. A hackathon could be coming up with operating procedures, sharing knowledge where we're still—but I think we've done a good job of—the IEEE went through a total revamp of all the technical committees and I'm really seeing some really good fruits of that work.

Julie Cohn (01:05:52):

Was that recent?

Robin Podmore (01:05:54):

Oh, just in the last, I think, in the last five years. Oh, I walk into a room, and I just can't believe the amount of talent that is sitting in that room from across the world, sharing ideas.

Julie Cohn (01:06:09):

That is exciting.

Robin Podmore (01:06:10):

But that's why I'm passionate about getting everyone a full model of the continental US that we can all play with. So that's—.

Jess Slater (01:06:19):

Dan, do you have any questions?

Daniel Molzahn (01:06:22):

Well, more comment than a question, but I'd say I can second your call for—I love the detailed model of the continental US. I think there's some efforts in that direction at the moment, but that would be very valuable.

Robin Podmore (01:06:35):

Yeah.

Julie Cohn (01:06:39):

Do you—I was curious about timeframe and technology, just pushing the topic a little bit more looking back. I've seen the data that was collected by Ty Dyliacco about who had installed what type of computing and control systems in their operating rooms across the 1960s through the 1980s. And the curve starts to go up pretty sharply towards the end of the 1970s in terms of digital technologies. That maps pretty closely with your work in terms of both EMS and training.

Any thoughts about the implications about the adoption of digital computing and how that changed the focus of work in your world?

Robin Podmore (01:07:48):

That Tom DyLiacco was just another amazing icon when you look at his background and how he built the system at Cleveland Electric. And then he—they had the Electric Power Computation Conference in a really nice place every two years. The professors didn't advertise it that much. He would always say, "We're going to have it in a really nice place," typically in Europe, and it would be a very select group. And then that survey, I don't think there's—I'm not sure if there's anyone publishing anything like that. But what we're seeing is a—it's almost a seismic change in that some of the vendors are saying: "we're going to resell our software through other value-added resellers and partners." And all of a sudden, the whole idea is that you're trying to build an ecosystem and own the platform and have lots of other value-added resellers is starting to take place. And now, that just happened in the last year. And I'm very optimistic about that. The whole idea is how do we take—we have such vast resources in this country with the budgets that the labs have, that the universities have—and how do we really get that into practice? And I believe this new move by the vendors is going to open up multiple challenges to make that happen. Yeah.

Jess Slater (01:09:29):

I just wanted to ask one thing. Going back to while you guys were talking about, Dan, sorry, I was, he can't see me, but talking about the operating certification questions and using that within the classroom. And so, as an industry person, in what other ways do you think academic institutions can better prepare students to tackle the evolving challenges in the industry?

Robin Podmore (01:09:55):

I think they should all get their students NERC-certified. All right. So at least they know the rules of the road as well as giving them all this theory. Right? But I've been preaching that for a decade now, and it's slowly catching on.

Jess Slater (01:10:09):

Thank you. Thank you. Any last, Dan, any questions? Or any from anybody?

Daniel Molzahn (01:10:18):

Oh well, I had a question that maybe is a bit of a tangent from something you touched on earlier. But you had kind of raised concerns about cybersecurity challenges at some point and terrorism challenges. And so these sort of malicious actor settings, kind of, what do you think the role of the industry is in preparing for those? And how do you see that sort of evolving going forward? I mean, the system from, at least my understanding, wasn't really designed in a way that worried about some of those issues so much, and now it's becoming more salient. So how do you sort of robustify the system in a way to address that?

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Robin Podmore (01:11:12):

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Because we have to build an implicit circle of trust. The defense security certification is not the way to go. So as we talk with NERC, we've got to figure out that there's a trusted community. And for me, it's, personally, it's difficult. Because my grandparents came from Guangdong. I'd love to go back there, but I don't, I don't think I can do it right now. Given the tension, it's sad to say, and I'm working on attack vectors that are outright scary. A sophisticated attacker could destroy every major transformer and could destroy every major generator.

Robin Podmore (01:12:19):

And the system blacking out is not the biggest risk. Once it blacks out, they won't be able to destroy any more generators or transmission lines, and we'll bring it back together in three to five days. And if the population behaves themselves, we won't have riots. And if we don't have, if we have extremes of weather, but the August—was it August 8th, 2003—blackout was relatively mild. Okay? I don't think there was a loss of life and people behaved themselves. But it could actually cause great long-term damage to our economy. It could be actually crippling battle loss of life. It could be horrendous.

Robin Podmore (01:13:02):

So I'm—DOE has funded. EPRI did really well. Ry got some major, major awards from the CESAR program. So we are putting a lot of funding in that. I need to go to EPRI. I need to explain to them what these attack vectors are. And there's a lot of, and just make people aware, I always go back to 9/11 commission. The major weakness was that there was a lack of imagination. That's the one that—and so really, we're able to imagine some attacks that, and so the idea is, and we've been working on these attack vectors for about five years. Now, I believe there's enough, there's enough vendors in place that can do the encryption, that can do the protection, where I'm not just crying wolf, there's a set of vendors that can really start putting the security, the encryption, and the defense mechanism in place really quickly.

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Robin Podmore (01:14:48):

And idea is, we've got to design the grid to withstand multiple outages due to Mother Nature. You can look at the EIA.gov map, and you can figure out, we can cut the power to an entire city by taking out five, 500 KV, 345 KV lines. So it's not like people can't see that. And you can do that with drones, where no one's putting their life at stake. So NERC is doing the Grid-X simulations, but that's only once every two years. And it's a paper drill. So I'll often say, think of our military, trained once every two years with a paper drill. That military wouldn't be very well prepared. So NERC's an amazing organization where, you think about it, it’s a bottom-up organization that lets volunteers drive the standards, versus a nationally owned organization that just does everything top there.

Julie Cohn (01:16:07):

I think we've reached the end of our time with you. It's been really fascinating. We've really enjoyed it. Any final question?

Sairaj Dhople (01:16:18):

Well, I would love to thank you again for your mechanical analogies. I think that was very insightful.

Robin Podmore (01:16:27):

Well actually I'll finish up with one if you don't mind. Where is my ruler?

Sairaj Dhople (01:16:32):

It's on the right side. That's right there.

Robin Podmore (01:16:34):

Okay. That's angle stability. Voltage stability. The US, it's like a big tent. You've got—I use these cable tosses that you see in Scotland. These strong guys are holding up power poles all well, and if they've got reactive reserves, they can keep that voltage nailed at a certain level. The loads drag the voltage down, due to the megawatt demands. And so what happens is you hit near the curve, and I have these simple rules, 500 megawatts over 500 miles at 500 KV. And that scales. It's 11 megawatts over 11 miles, 11 KV. And that happens at a 45-degree angle. Now, the key is once you start providing— The cities are all dragging down the voltage with real and reactive power. As we start, put all those grid-forming inverters out there, all those electric vehicles, to start holding the voltage up. And so everything will totally change. Our cities will become amazing suppliers of mega-var reserves and synchronizing torque. So it's that, to me, it's that simple. But there's a lot of education. We've got to train all the public, the automobile suppliers. But we're on the right track. It is like herding sheep in a lot of ways, or herding cats.

Julie Cohn (01:18:10):

You've given us both an optimistic and challenging vision of the future.

Robin Podmore (01:18:15):

Thank you. Thank you.

Jess Slater (01:18:16):

There's something you noted about the public—of informing the public. Can I ask a final question? How important is public perception in the development and acceptance of new power system technologies? And what strategies can be employed to engage with the communities effectively, particularly in the United States. Or anywhere else? Whatever you prefer.

Robin Podmore (01:18:35):

It's going to be huge. We're starting to see all the city councils. In San Diego, I guess there was an alert due to a potential fire, and people being exposed to lithium. And all of a sudden city councils are saying, no more batteries. And what we're finding is, in some ways we let the markets—we're actually looking at the situation. And I was talking to the guy running the power plants in Pennsylvania, and they have a capacity market. And if that capacity market comes in at $50/megawatt instead of a $100/megawatt per day, they'll shut down two really large coal plants. And they're not running right now. They're just like resilience units that—they're just there. But the people are making good salaries. So, it seems to me that the governors are not going to want to let the power markets just dictate what their resources are, the governors are going to—we're getting our way with a lot of lack of transparency right now.

Robin Podmore (01:19:48):

Okay? So I literally had the IBEW union guy saying: "I'm talking to the governor, what can we do about keeping these power plants?" And those were actual power plants that stopped the Northeast Blackout from not being just 60 million but maybe being 100 million. So again, people are not this—it's refreshing to see a lot of the executives coming through here with a strong technical background versus the days when you hired the lawyers and the accountants to get the rate increases. So we're seeing that technical confidence, but then we have to—well, that's something I preach to the Smart Village entrepreneurs. I say, "look, we've got to learn to communicate at the highest levels of government, academia, industry, and as engineers, we have to do a better job of that." And this is part of it of what you're doing, Julie, thank you so much.

Julie Cohn (01:20:50):

Well, I appreciate my colleagues for making this project happen.

Robin Podmore (01:20:55):

And documenting the history, the giants—the giants that we were sitting on their shoulders.

Julie Cohn (01:21:05):

We have many shoulders to stand on, including yours at this point.

Robin Podmore (01:21:08):

Thank you.

Julie Cohn (01:21:09):

Thanks very much. Thank you so much,

Robin Podmore (01:21:11):

Alright. It was a lot of fun.

[End of interview]