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Using Historical Analysis to Envision a Sustainable Future

Oral History Project

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***Abstract*:**

Mr. Nevius describes his education at Drexel University and his primary places of employment—Public Service Electric and Gas (PSE&G) and the North American Electric Reliability Corporation (NERC). He explains conducting transmission studies at PSE&G and at NERC focusing on assessment, planning, review, and blackout investigations. He mentions load growth in the 1970s, the oil embargo, resulting shifts in generating resources on the PJM system, and follow-on technical and operating challenges. He identifies the 20-year transition of NERC from an industry group in the early 1980s to the federally designated Electricity Reliability Organization after 2005 as the biggest professional challenge he tackled. New participants in the system, new uses of the grid, and challenges of managing and tracking power flows prompted the need for federal regulation. The process included consulting with entities outside the power industry, developing the Reliability Functional Model, engaging multiple stakeholders,

and persuading Congress to act. Mr. Nevius describes an alternative approach, called Plan B, involving voluntary commitment to standards. He discusses the significance of market changes beginning in the 1990s and how new participants learned about grid operations, hinting that some occasionally gamed the market. He stresses that the functional model reduces the likelihood of that happening today.

Mr. Nevius discusses NERC relationships with industry participants and other regulators. He describes emerging problems on the grid related to inverter-based resources. He notes that the use of phasor measurement units (PMUs) has enabled grid operators to better understand what is happening and where. Mr. Nevius also discusses the ongoing challenge of interdependent energy systems—particularly gas and electricity.

Mr. Nevius closes by urging non-experts to better understand how the grid works. He provides an example of a news reporter mistakenly stating that each state has its own grid. He encourages college students to think broadly about ways to participate in the power industry.

<u>Note regarding Transcript and Timestamps:</u>
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.

Julie Cohn (00:00:00):

This is Julie Cohn. I'm conducting an interview with David Nevius on Friday, January 12th, 2024, online. Daniel Molzahn, Mark Goldberg, Rachel Harris, and Rahul Gupta are also participating in this interview and may ask questions. Mr. Nevius, during today's interview, we will be especially interested in your work for the National Electric Reliability Corporation, I'm sorry, the North American Electric Reliability Corporation, also known as NERC, and the entities that proceeded it, including your blackout investigations, your work on legislative initiatives, and your work on the NERC Reliability Functional Model. But before we tackle those topics, we'll begin with some introductory questions and general background information about you. So, if you would, please describe your educational background and your professional positions in the fields of power systems planning, management, and oversight.

Dave Nevius (00:01:20):

Sure. I have a Bachelor of Science in Electrical Engineering from Drexel University with a major in power systems engineering and a Master's of Science in Engineering Management, also from Drexel. And I'm a registered engineer in the state of New Jersey, but in retired status.

Julie Cohn (00:01:41):

And tell us about the positions you've held over these years.

Dave Nevius (00:01:47):

I started work at Public Service Electric and Gas in 1969, and I worked for 10 years for PSE and G in the transmission planning division, developing plans for the high-voltage transmission projects that were put in place. And I also represented Public Service on several regional transmission study groups, including some of the PJM transmission studies. The one I remember most vividly was the 1973 to 1980 PJM transmission study, where we finally, or first realized that we could no longer dispatch the entire PJM footprint on an economic basis, and we had to come up with some alternates there. I also worked and had a great deal of interest in doing a study to wheel 600 megawatts from the northern part of Public Service system through the system and over to [the] Con Edison System at Farragut.

(00:02:45): It was an alternative to a DC cable that Con Ed was proposing, and we just used a split of savings concept where money was saved by not putting in the 600-megawatt DC tie, but rather doing some reinforcements in parts of Public Service's system. And it saved con Edison about $50 million at the time. At the end of my 10-year stint at Public Service, I did a two-year engineer on loan program with what was then called the National Electric Reliability Council, still called NERC. And then I took a full-time job with NERC in 1979 and spent the next 33 years there until I retired in 2012 as a Senior Vice President. Following retirement from NERC. I authored the 50-year history of the North American

Electric Reliability Corporation. And I'm pleased to say that that report now resides in the Library of Congress, I think in the business and technology section. So, that's a brief capsule of my work history.

Julie Cohn (00:03:54):

So, if you were to characterize where you fit in the industry, would you place yourself as a planner, a regulator, a manager, a theoretician? How would you characterize your role in the industry?

Dave Nevius (00:04:14):

I could say a little bit of all of those. Certainly, while my planning background was primarily at Public Service, I did oversee the NERC Reliability Assessment Program for a number of years, serving on what used to be called the Inter-Regional Review Subcommittee. Then, later, the Reliability Assessment Subcommittee, where we produced annual reports for the following 10 years of reliability issues and concerns in each of the regional councils that made up NERC. I did that. I oversaw a number of other groups, some special projects while at NERC. And then, as NERC entered these new, new era of self-regulation, I worked on the legislation that was eventually passed in 2005, which led NERC to be named the Electric Reliability Organization, with authority to set and enforce compliance with reliability standards. Along the way, I oversaw a couple of blackout investigations, the big one in 2003, and a somewhat smaller one, but still significant one in 2011 in the southwestern United States.

Julie Cohn (00:05:37):

So, reliability has clearly been a major topic area for all of your work. But looking back just towards your PSE&G years, it sounds like there was also some work on economics and optimization. Is that correct?

Dave Nevius (00:05:56):

Well, at least economics from the sense of splitting the savings regarding the 600-megawatt wheeling arrangement that from Public Service through to Con Ed system. And then, of course, the annual transmission plans were developed. We had to present those to the executives and to get approval for funding for reinforcing the system. At that point, the load was growing rather significantly throughout the PSE and G system. And a number of projects that were based on the whole PJM independent system operator footprint, including the deployment of four phase angle regulators in the southern part of the system to handle some reliability issues that arose at that time.

Julie Cohn (00:06:51):

For our non-technical audience, can you give a very quick explanation of what a phase angle regulator is?

Dave Nevius (00:06:59):

Yeah. It basically changes the power angle between two parts of the system and either draws more power through or holds power back. It's like a valve that you can open and close at different levels to let more power through or not. And we used it to optimize some of the flows and avoid having to reinforce certain transmission lines instead by basically rerouting some of the power. It still flowed over all the paths, but it created some phase angle differences that would block some of the power. And they were used quite effectively in the southern part of the system. We did a study with the various members of PJM at the time. I chaired that group and came up with a number of alternatives to deal with some of the overloading problems that were going to occur in the future. And finally, settled on the addition of these four phase angle regulators.

Julie Cohn (00:08:01):

Thank you. So, let's turn toward your, what you consider your most significant contributions to the reliability of power systems in North America. What would you say were the most challenging or important technical or reliability problems you tackled?

Dave Nevius (00:08:19):

Well, I think the big one, which really led to NERC becoming the ERO and passing legislation to put that into effect, was the changing industry. A lot of new participants came along; independent generating companies, independent electric power marketers who were interested in moving power from one system to another and getting paid for that. Of course, as all of your technical people understand, the power flows freely throughout the system based on the impedance of all the lines, but it flows simultaneously through all the systems. And as some of these independent power marketers would wanna move power from A to B, it flowed through not just the direct ties between systems A and B, but overall the paths in the system based on the impedance of all the lines.

(00:09:14): So that became a difficult problem. NERC developed a program to monitor where those flows were and who was being disadvantaged. There was a lot of some pretty serious arguments that went on about who system was being used. It wasn't just a contract path that was established by the power marketers, but all the paths were being used, and in some cases, some of the neighboring systems were disadvantaged by those flows. So that was one thing that really highlighted some of the challenges that took place early on. Those were dealt with in various ways. But I think the key to making this all make sense was the development of, you mentioned it before, the Functional Model. Before that, there were balancing areas, which could be anywhere from an individual utility to a power pool to a regional transmission organization.

(00:10:20): And some performed a number of different functions, a balancing function transmission planning function, the transmission operations function, et cetera. And the development of that model, and I characterized it in that history document that I wrote after I retired. And I characterized it as the Rosetta Stone because we then identified the functions. And an individual utility might serve a generation owner function, generator operator function, a transmission owner operator function. So on, a power pool might perform a balancing authority function, a balancing function, or again, a planning function of its own. So, by breaking it up into these components, these functional components, we were able to write standards not for control areas, which was what used to be the entity that we dealt with, to all of these functions, whether it would be transmission planning, operations balancing, or whatever. And the standards today are divided up into those functions. So, PJM, for example, would roll up a number of the functions or perform a number of those functions, and they'd be held accountable to each and every one of the standards that apply to those functions.

Julie Cohn (00:11:48):

Let me just back up for one sec. You attributed the challenge to the changing industry. Can you give some sense of when those changes started in the industry and what might have triggered those changes? Was it new technology? Was it new regulation?

Dave Nevius (00:12:06):

I think it was just the push towards competition. And there were new entrants in the marketplace that said building an independent generator and then selling that output to an individual utility or selling it out on the market. This would've been, I'm trying to think back now, time-wise, when that would be. Probably the early 1980s and maybe beyond. I'm not absolutely clear on that. But competition really changed the challenges to reliability that took place. And it caused NERC to do a number of things to try to address these challenges. But eventually we realized after some independent study was done and recommendations made that the only way to do it was to have mandatory enforceable standards. So, a reliability, what should I call it? A reliability oversight function with authority to impose penalties if necessary and with federal oversight. So, audited self-regulation is the term that is often used to describe what we moved to. But in order to get there, we had to have federal legislation in the US. And then since NERC covered all of North America, some of the provincial regulations had to change as well.

Julie Cohn (00:13:43):

So really, this took place over a period of about 20 years. Is that right?

Dave Nevius (00:13:50):

Yeah. It picked up some steam as we began to approach the '90s, and some of the challenges that came up where people would buy power from one plant cell power to somewhere else, and the flows would go over the entire network, and tracking those flows became quite a challenge. We developed some tools for doing that. But, still, it was a difficult situation until we could really separate things and, again, develop that Functional Model where we were dealing with functions, not with what an individual utility would be, or a power pool would be, or an RTO would be. And it was a challenging time to get through all of this. And then when we went out and talked to a number of different organizations that had some form of audited regulation or self-regulation—

(00:14:52): We talked to the healthcare industry through the Joint Commission on Accreditation of Healthcare Organizations called JCAHO. We talked to the nuclear power industry, NRC, in particular, for how they would maintain safe operations and nuclear plants. We talked to the Alliance for Telecommunication Industry Solutions and on and on from there. And finally, it was concluded, and we had an independent group do some reflection on this and made recommendations that we needed federal regulation in order to do this. And while there was general agreement on that legislation, as often happens in the development of legislation, people wanted to attach a number of other unrelated things to it. They go Christmas-treeing. And so even though we had good agreement on the basic foundation for reliability standards, folks wanted to attach to it some other issues or other provisions that were not universally supported.

(00:15:59): So, it was a challenging time. I facilitated a number of meetings where, where people in the West wanted to have their own set of standards and their own compliance program and so on. And there was a time when the legislation didn't pass each session. And we began to think we needed a plan B to develop some other means of doing this. Now, ironically, the West had had several serious blackouts, and they decided before this legislation ever came about, they decided they needed a reliability management system, RMS, they called it, not root means square, but Reliability Management System. And they had a number of standards put into that program. And they got their member systems. This is everything west of the Rockies, essentially.

(00:16:54): They got their member systems to voluntarily sign an agreement saying, If we are found in violation of the x, y, z standard, we will be held accountable. And whatever the penalty is, we would pay that penalty. And a little side story, I had the <laugh> the pleasure of presenting to the board our thoughts about a plan B in case the legislation never passed. And one of the board members said, “Well, Dave, wouldn't that work for all of North America and not just for the West? What would be the downside?” I said, “Well, there was nothing that really compelled the member systems to sign this agreement to be held accountable.” And this person who was a member of our board asked, “Well, who in the West had not signed the agreement?”

(00:17:48): And it happened to be Portland General Electric. And the board member who asked me the question was Jeff Skilling from Enron, who most of you would realize had purchased Portland General Electric. So, that was sort of an interesting thing. I never did see it in any of the books that were written about Enron. But thankfully we did move ahead with legislation. And myself, our president, and our general counsel, on a number of occasions, testified before various House and Senate committees and subcommittees on the need for the legislation. And finally, it passed and was signed into law in 2005. And then the real work began on redoing the standards, having them apply to all the different functions, and getting them approved by the FERC. And in a number of cases, they've had some suggestions to modify them. And that process continues today. There's standards on critical infrastructure protection, on all aspects of planning and operating the bulk power system.

Julie Cohn (00:18:57):

So, NERC itself, during those years that you were developing the Functional Model and other ways to approach reliability standards, was primarily an industry sponsored organization? Is that correct?

Dave Nevius (00:19:11):

Yes.

Julie Cohn (00:19:12):

It was people who were involved in the power industry, not all private sector entities, but it was the industry. And so, it—

Dave Nevius (00:19:23):

Was the industry. And we had a board of trustees that comprised industry executives, mainly CEOs from all the different sectors. We had investor owned, cooperatively owned, public power, federal utilities, like TVA and Bonneville, and Canadian representatives. So that is what comprised the Board of Directors. And then we had various committees underneath, which also had representation from all of these sectors. But one aspect of the legislation we developed was a decision that we needed an independent or unaffiliated board. And we did a search using a search firm and interviewed a number of people from all different walks of life, not just electric utility people, but others as well, business people. And eventually [we] added nine independent directors to the board, who served with all of the stakeholder members until the legislation passed. So, they came on in 1999, I believe, and it was 2005 before the legislation passed; but somewhere in between, we decided to go ahead and turn over board control to the nine independent directors and move the others into what we called a Member Representatives Committee. And they worked hand in hand with the board, but it was the independent board that made all the decisions from that point going forward, and still today.

Julie Cohn (00:20:56):

So, to what extent did the various committees interact with state level regulators in working out how to address these issues?

Dave Nevius (00:21:09):

Well, we had representation from all of the industry organizations, including NARUC, the Regulatory Utility Commissioner organization. So, yes, and on a number of occasions, I would make presentations on our various reliability assessment results to one or more of the NARUC committees at their annual meetings. So, we did keep them apprised of what our findings from these studies were. And they were supportive of the legislation as well. It didn't take away anything from them. Mainly the state regulators were looking at the distribution-level reliability as opposed to the bulk power system. But we did keep them fully advised about these developments and what the standards were.

Julie Cohn (00:22:00):

Did you have much input from people in academia, whether they were engineers or economists or political scientists?

Dave Nevius (00:22:11):

Somewhat. I can't think of any real specifics, but there was some work that was done in some of the national labs that fed into what we were doing. And certainly, we had some help from Pacific Northwest Labs when we did the analysis of the 2003 Blackout. We had a gentleman from there who worked closely with us, and there were some recommendations that did come from them.

Julie Cohn (00:22:41):

So, were there controversial issues beyond the one you described for the western utilities that plagued the process? And if so, which stakeholders? Not by name, if you prefer not to say, but which stakeholders might have been working against what you were trying to accomplish?

Dave Nevius (00:23:03):

Well, I think once we got agreement on the Functional Model, and that we would develop standards and enforce standards based on who performed each and every one of those functions, we didn't find much disagreement there because it wasn't based on the different ownership segments as it was on what functions each of them performed. And that was the real key to unlocking or solving this puzzle. Before that, there was a lot of criticism. The control areas had a lot of authority over what happened and how the system was being operated. But once we broke down all of the functions as defined in the Functional Model, those concerns went away. And then it was just a matter of writing the standards and setting the requirements appropriately.

(00:23:58): We did have a number of discussions with the American Wind Association, for example. And we talked about low-voltage ride through for some of the wind generators, which was an issue. But we gradually worked our way through it, but that mainly got solved by virtue of writing the standards and enforcing those standards. There's still some issues today regarding some of the inverter-based resources. NERC has done, after I left, a number of reports on some of the challenges of inverter-based resources. It's a technical challenge. There have been cases where either from wind turbines or solar farms, or generating DC and then going through an inverter to AC, something else happens on the system, and suddenly that inverter shuts down for a very brief period of time and then immediately comes back on.

(00:24:55): So, it's like losing a generating unit and then having it suddenly come back on and creating some stability issues for the system. I think NERC is working on resolving some of those concerns. And some of the new generation wind turbines and solar farm controls, they still need some work on, on this inverter-based resource issue. But I think NERC is making some headway there too. That changes some of the dynamics of the system too, especially if you're retiring some of the larger traditional generation, you're losing system inertia. The system is, I like to say, becoming lighter, and it's more prone to oscillations because it's lighter. And I think next week you have somebody who formerly worked with NERC—Bob Cummings—who's a real expert on this and different modes of oscillation.

(00:25:55): And it's changed. Usually, the operators get used to how the system performs. If you lose a generating unit or transmission line, they know pretty much what's happening. Their models are pretty accurate. But now with a lot of retirements of traditional generation, those modes of oscillation are not the same as they used to be. So, there need to be ways of monitoring them more closely. One of the things that I wasn't directly involved in it, but there were some phasor measurement systems put in place where they would collect this data and be able to model what's going on by using these phasor measurements. That was a real help to the system operators. It is more like an MRI versus an X-ray when it comes to operating the system. And I think there were some people at TVA [that] pushed this hard. There was a lot of phasor measurement units in place now, and had we had some of them in place prior to some of the blackouts. We probably could have avoided some of the things that happened.

Julie Cohn (00:27:10):

That's interesting. So, because we weren't able to measure what was happening, we didn't know that it was happening?

Dave Nevius (00:27:17):

Pretty much. Yes. And you could anticipate based on how things were changing and some of these phasor measurements; it's a tool for the operators. I'm not sure that we've really developed that information to the point where it gives the operator clear direction on what to do, but at least the operators have a better understanding of what is happening while it's happening, and then can take steps to either drop generation, drop load, or make whatever other adjustments they are able to make to avoid a problem. But the dynamics of the system are getting more complicated as new, well, especially as inverter-based resources are added. It's something that needs to be addressed.

Julie Cohn (00:28:09):

Before I go on, I'm just gonna pause and see Daniel and Rahul, if either of you have questions you wanted to ask at this point?

Daniel Molzahn (00:28:19):

So, I had a couple questions earlier on which maybe we can come back to later, but one question on this point that you're just mentioning, do you have a sense of how much coverage you would've needed of these PMUs? Were we pretty close with a couple extra PMUs, we could have met [and] avoided some of these blackouts in the 2000s? Or, were we sort of nowhere near having enough to be able to address that?

Dave Nevius (00:28:48):

Well, we never have enough, <laugh> but I think it's improved quite a bit. There've been a lot more added, but it's not just having the PMUs there, it's to gather that data and analyze the dynamics that are taking place in the system and translate that into terms that the operator can use to make whatever adjustments they can make. So, it's not just having the phasor measurement data, but actually the tools to analyze it, make some sense out of it so that the system operator can determine what needs to be done given what's happening on the system.

Julie Cohn (00:29:33):

Did you wanna ask your other questions, Dan?

Daniel Molzahn (00:29:36):

Sorry, I should have unmuted myself. <laugh> So maybe a quick follow up on that. So, do you think the theory and algorithms were at a place when we were first developing these phasor measurement units to be able to use them efficiently? Or are those things, at least from what I understand, sort of evolved in tandem, both the data availability and the sort of analysis methods? Or do you think we have the analysis methods already?

Dave Nevius (00:30:03):

Well, I think, again, next week when Bob Cummings speaks to you all, he can answer that question better than I can, but I think we've come a long way. But there's more that can and should be done to provide the operators with actionable information. I mean, it's one thing to know what's happening based on the data from these phasor measurement units, but then what do you do about it? And I think I think that’s where some real serious technical work can be done. And again, please ask Bob Cummings that question. He can tell you what is happening with respect to the data now, and how the data's being used, and how much or what else do we need to do to make better use of the data?

Daniel Molzahn (00:30:54):

Got it. No, that makes sense. So, it's good to know that he's the right person to talk to about some of the details.

Dave Nevius (00:30:59):

Absolutely.

Daniel Molzahn (00:31:00):

Maybe one other comment along these lines, and maybe Bob is a better person to ask this as well, but when we were making all these changes in the '90s and we're kind of transitioning to this different market structure and all these different players, did we understand, because we didn't, from what I understand, we didn't have great PMU coverage or existing visibility in the system then either. Was there concern at the time of the stability issues of bringing all these new players into the system, or from what you described, it seemed like a lot of the issues you were bringing up were these loop flows and other issues, [which] at least to me, it would be a bit more of a steady state concerns about who's using which parts of the system. Was there also concerns about the dynamics, or did we kind of know the dynamics of the system well enough? It was—

Dave Nevius (00:31:54):

And I think people became more aware of it as they saw events taking place on the system. They saw some behaviors that they hadn't seen before. And in some cases, they weren't quite sure why they were seeing the system react the way it was reacting. But I think over time, as the information became developed a bit more, not just more PMUs, but ways to use that data became available. I think it gave the operators new insight into why the system was behaving the way it was behaving. And I think that continues to be improved even today. And there's always more, because the system's changing, the characteristics are changing, and as people operate in different markets, different things the system undergoes, different stresses and strains and so on. And this data will be very helpful to the operators in understanding why things are happening and what they can do to avoid them becoming a reliability problem.

Julie Cohn (00:33:15):

So, at least two different things must have been going on in the 1990s. One was the changing organization of the industry with new entities generating electricity who were not part of vertical monopolies, and changes in requirements about wheeling across transmission lines and so forth. But also, and I assume, I have to go back and look at the data, there was an increase in the total amount of generation and use of electricity. So, was it possible to distinguish which of those two things was causing more of the new behaviors on power systems at that time?

Dave Nevius (00:33:59):

I would say, the load growth slowed. It used to have like seven, 8% a year, but it slowed considerably <Yeah>, over time, for a number of reasons. So, I would say it was more that the system was being used in different ways.

Julie Cohn (00:34:16):

Oh.

Dave Nevius (00:34:18):

And especially not just the new independent generators, but the power marketers who came in and we hadn't really caught up with having the right tools in place and the right standards in place to deal with this. But they were still making deals from point A to point E and point B, C, and D in the middle. They were seeing the consequences, and things were getting a little bit outta hand. And that's when we realized we needed to do something. Which is what's led to the Functional Model. I bring that up again, and then gave people a better understanding of what was happening and what they needed to do to manage the system more effectively.

Julie Cohn (00:35:07):

So, when you say, I think—

Dave Nevius (00:35:08):

It was more the market changes that took place.

Julie Cohn (00:35:13):

So, when you say "we" realized that something needed to change, I assume that means those of you working at NERC, but was it generally the industry incumbents who were saying, we've been doing things one way for a long time and it's worked well, but now it's not working?

Dave Nevius (00:35:35):

Yeah, I think the people operating the system realized that the system was being challenged now. And there were people, let's say, booking transactions from point A to point E. And not everybody in between knew. And of course, the old contract path didn't really apply anymore because the power was flowing over all the other lines in the grid, not just the ones that are the contract path. And that's why there was some sort of rudimentary tools put in place to manage that. That never really got totally solved. But that was a big challenge. Again, the system was being used in new and different ways, and that put the operators at a disadvantage.

(00:36:28):

They used operating the system, they knew what was going on. You start this generator and where the power's gonna flow and so on. And that wasn't the case anymore. And so more information was needed. And I think the industry's done a pretty good job of handling it. But it's going to continue to change as types of generation change. And some of the traditional generation with the spinning or rotating mass and the inertia that that develops, that helps to maintain the stability and keep you close to 60 hertz most of the time or all of the time. And we're gonna continue to face those challenges, and I think they can be managed, but we just need to recognize that [there] are challenges to the, let's say, the stability of the system.

Julie Cohn (00:37:18):

So, oh, go ahead, Dan.

Daniel Molzahn (00:37:21):

Maybe one follow up on that is, did you have some sort of educational campaign or educational mission? You had all these people coming into the system, many of whom presumably were not folks with a strong power engineering background, if maybe they're more economists or people that maybe didn't solve circuits in their undergraduate degrees. And this concept of, well, we can't directly control where power flows, it flows according to every path of the system. Was there some effort to try to educate these new entities that were coming in about how the system works? Or was it that they figured it out and you set the standards and they had to follow?

Dave Nevius (00:38:05):

Well, it's probably a little bit of both. I think over time, some of the new entrants, especially the power marketers, began to realize that they weren't gonna be able to do business if the lights go out. And then the standards of course, applied throughout to all of the functions that were being performed. And once people started to realize that they would tend, they knew that they had to follow the standards, or the markets wouldn't work. You wouldn't be able to do your business if the lights keep going out because of the strains that were being placed on the system. So, I don't know that they necessarily became accomplished electrical engineers, but they were more business people.

(00:38:58): They were looking at buying and selling power and so on. And to be frank about it, there were some games that were being played. People would schedule a transaction that created congestion on the system, and then they would schedule another transaction that would take advantage of that congestion. And I think a lot of that has been resolved, and the system is operating reliably in spite of some of those things. But I think the business people realized it wasn't like moving other goods and services around, over transportation paths and so on. It’s a different system. And there was some education that took place. There wasn't like a formal program to educate people on it, but over time, the discussions that took place at the NERC committee meetings, the operating committee, the planning committee, and certainly at the member representatives committee level, and then eventually the board people realized that they needed to follow the rules.

(00:40:10): And there would be not only reliability consequences, but financial consequences if they were found to not be following the rules.

Julie Cohn (00:40:21):

So, when you all designed the Functional Model, my understanding is you were striving for both responsibility and flexibility so that it could accommodate many different types of organizations who were in some way participating. And you also talked a little bit about how the way the system was being used back in those days was evolving. It strikes me that it's evolving even more now because we're imagining a future world in which people buy electricity to charge their car and sometimes sell electricity back from their car. Our daily lives are infused with all sorts of gadgets that require electricity that were never being charged-up in the past. We have storage batteries that are becoming more and more useful, which we never had for the past hundred-plus years. So, do you see the Functional Model as sufficiently flexible to accommodate these changing roles of generators and users as well as the changing technologies?

Dave Nevius (00:41:33):

I do. The one gap in this whole picture is the interdependency of electricity and natural gas. There's not a lot of standards that apply to natural gas producers or pipeline operators. And there's issues going on right now talking about this, this issue during some of the cold-wave incidents that occurred last winter, Christmas Eve. What happened is the pipelines had moved gas from where it was, where it came out of the ground to where it was being used, were being fully occupied, fully used for local distribution, gas distribution, utilities, home heating and so on, to the point where some of the generators who had not purchased firm transportation of gas, they couldn't run, even though they had promised their balancing authority that there'll be firm supply, and they'll turn on the combustion turbine when the need arose.

(00:42:50): They didn't have the gas because the pipeline infrastructure was insufficient. And we're trying to work around that. But still, it's a big problem, this interdependency and in fact it's probably not a surprise that back in the 2021 cold wave that hit Texas, there was some issues that came up there where ERCOT, the operator of most of the Texas grid, had to employ interruptible customers. They had to interrupt Interruptible customers at one point because they didn't have sufficient supply. They had lost a couple of large units for various reasons. And what they realized after the fact, and to their chagrin, is some of the interruptible load that they interrupted was a load that was aggregated by these aggregators.

(00:43:51): And they weren't sure, they didn't know at the time. They do now. They didn't know at the time that some of the load that was being aggregated [were] gas compressor stations that were operating on electricity. So, when they interrupted the load, they also wound-up interrupting some of the gas flow because of it. And now they realize that, and they corrected that problem. But the interdependency issue is, in my mind, a key issue, and it's very difficult. There's work by the North American Energy Standards Board, NESB is the name of it, where they have representation from electric and gas at the wholesale and retail level. They're struggling with this right now. And there was a paper written here back in July talking about harmonization of electric and gas systems.

(00:44:42): The electric system has lots and lots of standards. The gas system does not. And they have safety standards, but that's probably about as far as the standards go. And it's gonna be a continued problem, especially in the winter, when the pipelines are being used to move gas to the gas LDCs, local distribution companies. And we don't have enough pipe space, if you will, to move the gas to those needs as well as gas for the generators that promise to operate when they are called on. So, and NERC is aware of it, they've done some reports on this issue. I think it's a major one, and it's looming out there as we retire more and more of the traditional generation and we're depending more and more on gas fired capacity, not there's anything wrong with it.

(00:45:45): But if they can't get the gas when they need it because the pipelines are filled up and there's not enough pipeline space, then what's gonna happen? And the load shapes are changing. And years ago, was a winter peaking system, then it became more of a summer peaking system when air conditioning loads picked up, and now we have almost two peaks, a summer peak and a winter peak, which are pretty close to each other more so than they ever used to be. And so, I think some particular attention needs to be given to the winter conditions because gas is so important to have adequate supplies gas-fired generation.

Daniel Molzahn (00:46:36):

So maybe a follow-up question on this is, it seems like at the beginning of your career there, there's the OPEC energy crises, and there we saw the oil infrastructure, for different reasons, having a big impact on the power grid. Here you're describing the impact of the natural gas system on the electric power grid. Are there other infrastructure or multi-infrastructure problems that you'd see beyond natural gas systems that could have similarly sized impacts on the system, maybe in the past or in the future?

Dave Nevius (00:47:15):

Well, I think we're still learning about how some of the wind and solar systems interact with the electric system. And we don't have that much of it in most places, but where we do, we're starting to learn that there are some issues, not just the inverter-based resource issues that I described earlier, but just, is there enough of this type of capacity? You hear often that some of the developers have backed away from projects off the coast of New York. I know there was a big wind project, the developer backed away for various reasons. They said, Financial and regulatory and whatever. So, what are we gonna be depending on going forward?

(00:48:11): I still have some hope that some of these small-scale nuclear facilities will be developed. I know there's a lot of talk about it, and there's some that are in operation that gives some hope there that we can supplement our system resources with them, especially as other sources are shut down or not available. But I don't see a lot of new large nuclear units being developed. I know the Southern Company was developing two more units at Plant Vogtle. But it's very expensive, and there's a lot of attendant issues as far as spent fuel and what you do with it and so on. But these small modular nuclear plants, I think, are something that's gonna have to be counted on going forward.

(00:49:08): I don't know a lot about how many of them are in place now or what the plans are going forward, but they're as green as green can be, if you think of green energy. I hate to see it when they talk about nuclear waste. It's spent fuel. It still has some energy in it. And maybe we'll see a time when we begin to reprocess some of the spent fuel. Years ago, they would talk about it over in France. They did have a breeder reactor, and they went totally nuclear to get off of oil. But there was talk about doing it in the US or in North America, but it hasn't really turned out that way. So, I think we're gonna see some changes to the characteristics of the system, the supply characteristics going forward. Again, gas is gonna be important. There's still some coal plants, some of the existing nuclear to make sure that they continue to operate well and maybe some small nuclear as well as solar and wind. And it's gonna be a whole menu of supply sources that are gonna have to be counted on.

Julie Cohn (00:50:26):

Dave, you were working at Public Service Electric and Gas. If I have this in my notes correctly, during the 1970s, to what extent did the energy crises in that decade affect the work that you were doing there?

Dave Nevius (00:50:42):

The one that affected it the most was the oil embargo, because there were very heavy west to east transfers of power across the PJM grid, applying energy to replace the oil-fired generation in New York, New England, and Eastern PJM. And it created some serious voltage problems. I started looking at some of these things just from a Public Service perspective, but we had voltages at one of the 500 kV substations that were down to 450 kV, which was quite low. And so, we formed a little study group to look at what happened and run some models to see what could be done. Eventually, they had to limit how much power could be moved from west to east to replace oil-fired generation that didn't have the oil.

(00:51:46): But we found that we weren't managing our voltage and reactive conditions as effectively as we could. In other words, in PJM, there were a number of 500 kV lines, and then step-downs from 500 to 230 kV. And we found that some of the utilities along the way were operating to control their 230 kV. But it was pulling reactive power off of the high voltage system, off of the 500 kV and depressing those voltages, which created some problems. So, we developed some very rudimentary guidelines for the PJM operators to set the low tap changers on the 500 to 230 transformers to maintain a good profile on the 500 kV system. There was one case where the tap changers were being operated to bring up the voltage on the 230 system, to the point where some of the generators on the 230 system were operating in lead. They had to be managed differently.

(00:52:57): And we gave the operator some guidelines, again, very rudimentary, not very sophisticated, but they were effective in having a good 500 kV system, a strong system. Because that's where your major power flows were going to come or be handled. And that was an interesting thing. I remember <laugh> just as an aside, we used the PJM computers to run all these studies. And of course, during the day, there wasn't a lot of time left 'cause these were the operating computers, so we ran a midnight to 8:00 AM shift. So, we were down in Valley Forge at night running so we could get time on the PJM computers to do all these studies that we ran. And it was [a] pretty effective, again, very rudimentary plan to manage the tap changers coming across from west to east. And it helped, but it was the oil embargo that created this demand for heavy west to east transfers. So that problem, I guess, has been solved by more sophisticated means than what we came up with. But it was something that I was directly involved with.

Julie Cohn (00:54:06):

Well, it's interesting that an international crisis resulted in a regional technology problem that was solved with an internal policy for operating the system.

Dave Nevius (00:54:25):

Yeah. It was, and again, it was just making people aware. They had some guidelines that they were told they need to control the voltage at the 230 system. So, they would just change the taps and they get that voltage up to where it needed to be. But the cost of that was, they were dragging reactive power off of the 500 kV system, which was causing those voltages to be depressed. And these transfers were pretty heavy. They were beyond surge impedance loading coming across from west to east. So, they were really chewing up on a lot of reactive power along the way. But that was an interesting little side issue that we dealt with. We also got involved in some other studies.

(00: 55:13): There was an Electric Power Research Institute project on putting batteries in some of the substations and [we] had to do an evaluation of how much we would save by putting batteries, because it would defer the installation of a new line. If you could hold that off, you'd save money by not having to add more transmission if you had batteries. There was a battery energy storage program that Public Service was involved in. They had a test facility that would test different types of batteries. I don't know where that program is today and how much battery energy storage there is. The storage is good, especially if you can move power in and out. The utilities that are in the best position have other energy storage opportunities or facilities like pumped hydro, [which] is ideal. Pump hydro system. I think Dominion Energy has some, a big pump hydro facility. It's great for managing the system. It's worth its weight in gold, but you don't have pump hydro capabilities everywhere. It just happened to be a quirk of nature, if you will, of why they had what they had there. But it really was an asset to be able to control the system. So, its system control is really the key.

Julie Cohn (00:56:44):

Dan, it looked like you had another question.

Daniel Molzahn (00:56:46):

Yeah. Maybe going back to this voltage issue that you had from these transfers. Were those anticipated? Had [you] done studies ahead of time about these transfers and you knew that it was gonna be a problem with the voltage issues, or—

Dave Nevius (00:57:01):

Well, every season they would do a voltage study, and they come up with recommended voltages for the 500 and 230 systems in PJM. But when you put these heavy transfers that were not anticipated on the system, the lines were loaded well beyond search impedance loading. And so, they were chewing up VARs pretty aggressively. And so, they couldn't maintain the so-called voltage schedule. So we took a different approach to this and said, Look, what you need to do, you need to manage this to keep the voltages on the 500 up as high as you could, and then, if it means you had to produce more VARs from generators down in the lower voltage system, so be it. But you wanted, if you're gonna be transferring that much power on the 500 kV system, you needed to keep the voltages up because if you're loading it beyond surge impedance loading, you're just chewing up vars and then the voltage is gonna be depressed.

(00:58:04): Like I said, transfer voltage, that was a PS 500 kV substation. When I got involved in this and started looking at what was going on, there were days when the voltage was down to 450 kV, which I don't know what that [was] percentage-wise, that was pretty low. That was not what how the system was planned to be operated voltage-wise. But I think we learned a lot from those types of events. And we continue to learn. Every time there's a blackout of any size, we learn a lot from [asking], why did this happen? Why did that happen? And what should have happened? And did the operators know what was happening? And were the state estimators working properly?

(00:58:49): And even the 2003 Blackout, we know where it all started, but it should not have spread the way it did. But one of the reliability coordinators couldn't get their state estimator to converge because there was a line somewhere else outside their system that was out of service. And as a result, they couldn't get their state estimator to converge. So, they were sort of blind to what was going on. Had they not been, had they been able to see what was going on. They could have taken steps to reduce load, even to shed load and, if necessary, to get the loadings on key line, the Sammis-Star line. I think there's a lot of reports on this, the details of it.

(00:59:34): And had they been able to avoid that line, tripping the blackout would've not extended as far as it did. But we learned from that. We learned a lot from that. A number lessons were learned. And I think the one in the Southwest, again in 2011, I learned a lot from that. There was one earlier than that up in the Northwest. It was a single cottonwood tree in the middle of an empty field. And the heat of the day caused the line to sag, and it touched a single cottonwood tree and tripped. Unfortunately, the parallel line on the same tower also tripped, of course relay people say, "In sympathy," I don't know if relays are sympathetic, and they were due to replace that relay on the other line, and they hadn't gotten around to it yet. So, we got round to it and sympathetic relays and so on. But you learn a lot of lessons, and the key is to learn to put those learnings into play, so that you don't repeat the same mistakes in the future. So, not that blackouts are a good thing, but they are a great learning experience.

Julie Cohn (01:00:56):

Mr. Nevius, have you ever worked with models of systems to understand how a blackout might occur, as opposed to working with the data from a blackout?

Dave Nevius (01:01:10):

Oh, sure. We would run a number of load flows and stability studies to postulate what would happen if you had a single contingency or a multiple contingency or a trip with a delayed clearing time and so on. All those studies are done regularly by the industry at all different levels, individual utility levels, power pool levels, regional transmission organization levels and so on. And there's a series of tests that are done based on the standards. You have to be able to withstand certain contingencies and not go unstable or not overload other facilities. So those are being done constantly, not only for the existing system today, but looking forward to what the system is expected to look like in the future. We run the same kind of studies on them as well.

Julie Cohn (01:02:07):

Do you remember what the earliest models were that you interacted with?

Dave Nevius (01:02:14):

Well, at Public Service they had a load flow model, I think it was called a Gauss Seidel model. Some of the folks from Georgia Tech may remember that name, but then they later adopted a different load flow model that was developed by a gentleman from American Electric Power. But you would set up your data, you'd have your impedance data, you'd have the generators modeled and so on, and you'd run various contingencies, take this line out, does anything else overload, and so on. So, you do that, you do that all the time. You do it at the local utility level. We did it at the power pool level, even at a multi-regional level. There were studies that were done, all different levels were done regularly to see, anticipate what would happen. And that's what all those studies were about.

Julie Cohn (01:03:10):

Did you ever work with analog computers as opposed to digital? Or was it all on digital machines?

Dave Nevius (01:03:21):

At Public Service? It was all on digital machines. However, <laugh> while I was still in school at Drexel, we didn't really have some models we could use. And we, myself and another fellow student, this would've been about 1967 or '68, there were people getting rid of their analog computers. There were a couple of 'em that were being abandoned, if you will. They weren't being used. They were being displaced by other types of computer models. And we went and looked at the different ones to see how you set it up. And the one that we recommended that Drexel take to use as a study tool came from a relay company down in Philadelphia.

(01:04:18): I've forgotten the name of it at the moment, but you would set up your study, you'd put the impedances in and so on, and you'd basically run like a little electric system and you'd take a line outta service, you see what happens. It was a great learning tool, because otherwise you didn't really have the same feel, just looking at some green stripe paper, which is what was used at the time. <laugh> Before I got there, Public Service did have analog computers that they ran. And they did a lot of their studies on that, but eventually it got replaced by digital computer models.

Julie Cohn (01:04:56):

I have just two more questions I'm going to ask that might close out the conversation, but I'm gonna check and see, Mark, Dan, does anybody else wanna ask something first?

Daniel Molzahn (01:05:12):

I did have a couple other questions. Julie, I guess if you have questions that are along the same line, I had a couple that go back a little bit further in the discussion.

Julie Cohn:

Okay. Go ahead.

Daniel Molzahn:

So, one of the things you had mentioned early in the discussion was how you were having had this plan B, in case the Energy Policy Act in 2005 wasn't passed, and you didn't have authority to compel people to follow the standards. Was there analysis done at the time about compliance by most of the system; most of the entities in the system are complying with the standards, but some are not? And then what sort of worst-case behavior or how that might impact the system to have a small number of entities not follow the standards? Was that looked at or—

Dave Nevius (01:06:07):

Well, our plan was, since we couldn't force anybody to do what they didn't want to do, our plan was to try to use whatever leverage we had to get everybody to commit to following the rules, or be held accountable if they didn't. Now, we never had to employ that. It was used in the West, their so-called Reliability Management System. It was pretty effective because most everybody signed an agreement to be held accountable. They weren't always happy about it, but it was a way to avoid some of the problems and repeat some of the blackouts that occurred in the West. They had a number of problems prior to legislation being developed. But it was just a short-term fix. It wasn't an ultimate solution.

(01:07:02): And I think most people realized there had to be something more formal than that, in the way of federal legislation. But the compliance by contract only works if you get everybody to sign on. I mean, at least all the major players could have some smaller entities that don't really affect the grid reliability that much, but I think they realized that to make this work, everybody had to comply. And therefore, the only way to do that would be to have federal legislation in place with clear compliance monitoring and enforcement. And this wasn't trivial. I mean some of the fines that were imposed could have gone up to a million dollars a day. This was not trivial stuff. It wasn't a slap on the wrist. It was pretty serious. And there were a couple of 'em in the vegetation management area that were fined. They hadn't maintained their trees, and that was one of the key initiating causes of the 2003 Blackout.

Daniel Molzahn (01:08:17):

Got it. That really interesting. Another question kind of in parallel along that is, you had mentioned the provincial governments and so Canada having to be brought on board with this as well. Was there concern at all, or thoughts about, if we have these standards in the US and maybe different standards in

Canada, or the Canadians didn't follow along, or what did that process look like when working across the country?

Dave Nevius (01:08:44):

No, they were the same standards applied, but the enforcement mechanism was a little bit different. The provincial governments were the ones that really paid the most attention to this. And each had their own program for monitoring compliance with the NERC standards. They still were obliged to follow the NERC standards, but the method of enforcement was different for each province. And there wasn't anything at the federal level, because most of the trend, most of the lines run north to south from Canada into the US, from the Canadian province into the US states. And so there was a joint US-Canada agreement for this, because I remember speaking to a number of the provincial government folks about how this would all work. And they each have their own enforcement mechanism. It's different than what it is in the US, but still the same set of standards apply. The way they're enforced are a little bit different in Canada and the different provinces of Canada than they are in the US.

Daniel Molzahn (01:10:04):

That,

Julie Cohn (01:10:07):

Oh, we lost you, Dan.

Daniel Molzahn (01:10:09):

I have to ask a couple more questions. Julie, do we have time?

Julie Cohn (01:10:19):

It's up to Mr. Nevius.

Dave Nevius (01:10:22):

I'm here.

Daniel Molzahn (01:10:23):

Okay. <laugh> Well, another question I had is we had interviewed earlier at the General Meeting last summer Janusz Bialek who, among other things that he worked on, he is fairly well known for doing some electricity tracing ideas of when you have these inadvertent flows and loop flows through other parts of the system, can you try to identify who's responsible? And so, from what I can understand, it seemed like there was quite a bit of effort on the academic community trying to grapple with that problem. I guess what I was wondering is, was there much transition between those ideas from the academic side and industry and national labs? Was there exchange of ideas on how to mitigate those issues? Or were people kind of working in silos in a sense about those problems, presumably in the '90s, I guess.

Dave Nevius (01:11:16):

Yeah, I don't know what was going on within the academic community about this, but we did have a program that was put in place to sort of track the flows. And to see where, who was being impacted. And there were some agreements among small groups of systems for how to compensate each other. In other words, if I wanna move power from A to D and some of the parallel systems that weren't part of the financial arrangement, they were impacted 'cause of the flows, some of the flows on their lines, they had some arrangement either to compensate each other or to agree to back off transaction to avoid causing reliability problems on a parallel system. But again, there were a number of agreements, I forget what they were called at the moment. But especially in the PJM area and some of the systems to the west of PJM, they were the ones that were impacted most significantly by some of these parallel path flows.

Daniel Molzahn (01:12:33):

Got it. That's really interesting to know as well. But I—

Dave Nevius (01:12:38):

I didn't remember anything from the academic community that was coming in to help with that. I think we did a work around, and there were some side agreements that were put in place to monitor where these parallel flows were coming from and going to, and an agreement to back off a financial transaction from A to D if it was gonna adversely impact somebody in between.

Daniel Molzahn (01:13:07):

Got it. I see. No, that makes sense. That's good to know.

Julie Cohn (01:13:10):

So, it sounds like the solution was a business solution rather than a technical solution.

Dave Nevius (01:13:16):

Yes. Because the technical solution is, <laugh> you have overloads on the system, you have to shift generation or drop load to solve it. That was the technical solution. But the business solution was, you just don't schedule it in the first place if it's gonna overload the line. There was also an issue called hubbing and parking, which was interesting. And some of the marketers would buy power from A, ship it to B, and then they have another deal from B to C, another deal from C to D. And you weren't quite sure this whole string of transactions without any recognition of how the flows were going to occur throughout the whole interconnected grid. And that was another one of the problems that they had to deal with.

(01:14:07): So, it's where business and technology sort of came together, and they worked out some arrangements; but now with the standards we have in place, this isn't supposed to happen. And people realize that they can't use the grid like it's a pipeline system. Because It's not, you can't control where it's going. And except at the FDC, but in any event it's interesting. This reminds me of something else that Julie, if you don't mind, a couple of weeks ago I was listening to the news, and I think the show was on Fox. It was called the Evening Edit with Elizabeth McDonald. And she was talking to somebody, a Congressman from Florida or somewhere about critical infrastructure protection and people hacking into the system using artificial intelligence and so on.

(01:15:04): And she made a side comment, which just made my ears perk up. She said, “Well, every state has their own grid and they're not interconnected, and that's a good thing.” And I said, “What?” <laugh> I said, “That's not true.” So, I thought about it for a couple days. Finally, I wrote a little email to Fox News feedback saying, I heard her say what she heard or what she said, but I said, “It's incorrect.” And then I described the four interconnected grids that encompass North America, Quebec, most of Texas, everything west of the Rockies, and then everything else, the eastern Interconnection. But people don't have a really good understanding of how this grid works and how these interconnections work. And it struck me as really a shortcoming of some of our news media who go around with this notion. I don't know where she got this notion, but the notion that there's all separate grids. Every state has their own grid. And that's certainly not the case.

Julie Cohn (01:16:14):

Did you have another question, Dan?

Rahul Gupta (01:16:16):

Yeah, I can, yeah.

Daniel Molzahn (01:16:17):

So, I think Rahul did.

Rahul Gupta (01:16:18):

Yeah, I had a related question with Dan, have you seen evolution in interaction with academia over the years? Like, as you mentioned that at the time there wasn't much input from academia. So, have you seen this evolution over time and there is a more need probably now?

Dave Nevius (01:16:40):

I think that there's more now. I couldn't point out specifically, there was one thing that I heard of, or it came to my attention here just a little bit ago, and I'm trying to get my brain to go back and remember what it was. But it was something that Argonne National Lab, oh, I know. It had to do with the interdependency of gas and electric. And Argonne had developed a model that you could model sort both the electric and the gas systems together, so you would know when you might be getting into some difficulty where some of the power plants wouldn't get gas and so on. Nothing much came of it. It was mentioned in this report that was done under the heading of North American Energy Standards Board, NESB, and Pat Wood, former secretary, or former chair of the FERC, I forget the other two people that led this group.

(01:17:48): And there were a number of recommendations. And one of 'em was that we need the national labs to do some studies, so we could have better models, so we'd know about the interaction between electric and gas. There was one example there. And again, I keep referring to Bob Cummings next week, he can tell you about some other work that's been done in academia that has application in the industry. And he's much closer to that technical area than I am. But there more, and there's probably potential or opportunity for even further work in that area.

Daniel Molzahn (01:18:28):

So just to make a small personal side note, that was my former group at Argonne, so I'm glad to hear them get a call out. Those are my former colleagues there. <laugh>

Dave Nevius (01:18:38):

Yeah. I forget what the name of it was. It had sort of a catchy name. But the gas industry doesn't have the same kind of standards. They have safety standards, but the comment I heard attributed to somebody in Texas when talking about having a gas desk in the ERCOT Control Center to keep an eye on what was happening with gas, not just gas production, but also gas transportation within the state. And the comment from the gas industry was, over our dead body. They don't care to <laugh> have a lot of regulation of what they do.

Julie Cohn (01:19:26):

So, unless somebody wants to add any additional questions, I'm gonna ask two closing questions that are kind of very broadly framed. So, you've dedicated your professional life to improving the reliability of power systems, bringing together diverse stakeholders to find policy and regulatory solutions, integrating technology, business, government into single platforms that will keep all of us well-lit and well-warmed or cooled, as needed. <laugh> What would you like Joe or Jane Public to know about this professional trajectory that you've been on all these years and the importance of it?

Dave Nevius (01:20:23):

Well, I think it'd go back to the comment I made about Fox News. People don't understand how the grid works. They don't understand. They think, I don't know what they think, but they don't understand it. I don't mean from a highly technical standpoint, but just that it's a big machine. I think somebody was quoted years and years and years ago saying, “It's the most complex machine ever devised by man.” And the reason that the power that you have in your house is maintained pretty close to 60 hertz all the time, it's not an accident,that's the way the system is designed, and that's the way the system is operated. And people just think reliability is just whether a tree hits a line outside their house or something else like that.

(01:21:14): I think more attention to simplifying how the system operates so people can better understand it. And also, some of the interactions with other systems. Other systems, the telephone system, the banking system, they all depend on a reliable supply of electricity. And then, of course, the electric and gas issue this report that I was trying to remember the name of, it's called Gas Electric Harmonization Forum Report. And that's the one where the recommendation about Argonne and the model that I can't remember the name of was developed. But I think [the] general public needs to have better understanding. And the fact that somebody at Fox News, through no fault of their own, has this notion that every state has its own grid. And it's not the case. So whatever folks can do to help explain something simple that John Q Public can understand how it works and why it works the way it does most of the time. So anyway, that's what I answer your question, Julie.

Julie Cohn (01:22:36):

Mark.

Mark Goldberg (01:22:36):

Yeah, I have a follow-up representing John Q. Public. Can you describe what you would want the public to understand, and relatedly, is there a danger, if any, in the public not understanding how this works?

Dave Nevius (01:22:58):

Well, I don't know if there's a danger in them not understanding. But people have certain notions about how things work, and they make decisions based on that notion. And if they don't have an accurate understanding, they may be promoting something that isn't in their own best interest. Again, I don't wanna make electrical engineers out of everybody. That wasn't what I meant, but just to have some basic knowledge. I mean, I've talked to school groups about it, and a lot of 'em, they don't understand how's this all happen? And why do we get 60 hertz power? And what happens when a line, a transmission line trips out, and how the system automatically readjusts the power, instantaneously finds other paths to flow; if one line goes outta service, people don't understand that it's just something that, that isn't well understood. So, I don't know whether the academic community can help in that regard or not, but it can’t hurt to have a better-informed public just on the basics of how this complex machine operates day in and day out every minute, every second of the day.

Julie Cohn (01:24:34):

Dan, did you have one more?

Daniel Molzahn (01:24:37):

I did have one other question. One other comment. So, it's the software or the tool at Argonne, is this NG Fast? That's the—

Dave Nevius (01:24:45):

That's it, that's the one, yeah. I found the report, and I was looking in here if I could spot the name of it, but yeah, that's the tool. It depends on having a lot of flow data from the gas industry. <Mm-Hmm>. And I don't think the gas industry is very inclined to let others know what's going on in their system. They kind of hold it tight to the vest and so on. <Yeah.> Yet there's such a close relationship between the two industries, and they depend on each other. Back in the early '90s I put together a group of electric and gas people, and we had a gas pipeline person on it as the co-chair and an electric system person on to be the other co-chair.

(01:25:41): And one of the things that I remember very vividly is Florida Gas transmission, which maybe is an Enron company, they had their EMS system directly tied into the Florida Power and Light EMS system. Not for anything economic, but just from a system information standpoint. And the reason was, if a nuclear plant in Florida were to trip out, all the combustion turbines would come on suddenly to replace the lost electricity supply. And without other information, Florida gas transmission would think that was a pipe rupture, and they would shut all the valves, which would be the last thing you'd want to do. Because you'd shut down the electricity in the state. And they decided that they needed to share certain operational information with each other. Now, I don't know how many other gas transportation systems and electric systems share that kind of information, but that's what this tool would help with if folks could be willing to adopt it and to put the information into it, the data into it that you need to operate it.

(01:26:58): But anyway, I remember that study, so the electric people learned a lot about gas, and the gas people learned a lot about electricity. And it was very valuable. It never really came out with too much in terms of formal recommendations. The only thing specific is we asked all the pipelines who had electric compressor stations to go back and see if their supply was a firm supply. <laugh> And whether it was on an interruptible list, which turned out to be the case back a couple years ago in Texas. But in any event, it's one of the issues that we're gonna live with for a while. Because we're gonna have gas, we're gonna have electric, and the two of 'em are very interdependent.

Daniel Molzahn (01:27:57):

It’s really fascinating that there's an example where that was successful. I think that's really nice to be able to point to someplace where that intersection was well done.

Dave Nevius (01:28:10):

Yeah. But again, it's difficult because from a business standpoint, not wanting to share what we call or might be thought of as business-sensitive information, but you've got two systems. One is a network. The other is a series of pipes. Some of the gas systems are networked as well, but usually, by opening and closing valves, you can move the gas, you can redirect the gas if you have a problem. But the two systems have to work together. They depend on each other. The electric system needs the gas supplier for its generation and the gas system needs the electricity run their compressor stations. So, in any event, that's just one little example that something that I remember from many years ago now.

Julie Cohn (01:29:08)):

So once upon a time, you were an eager young power systems engineering student in a classroom at Drexel University. Imagine all the hundreds of really talented youngsters now enrolling in power systems engineering across the country. What advice would you give them?

Dave Nevius (01:29:30):

Hmm. I think they need to have an appreciation for how this unusual machine works. And there's all different parts and pieces that are important, the control systems and so on. How things are planned and some of the challenges and risks. But there's quite a broad field of endeavor that people can get into. It's a key resource for our country. It keeps things, keeps industry working. So, it's an important thing. And I think there's a lot of different facets to it, whether it's in the power system relaying area, that's one area, the other control systems. Looking at how some of the new technology is integrated into the system, not just how much, how many kilowatt hours can be generated by wind and solar, but how do these systems work together?

(01:30:42): And do they support continued synchronous operation of the grid without causing stability problems and so on? So, I think there's a lot. More than I would've imagined back in the mid-sixties when I was in school learning about some of this stuff. And there's a lot of different aspects of it that need to be developed. There's some schools that have some programs. I know Lehigh University has one where they call it Energy Systems Engineering. And they sort of couple, or they look at both economics, environmental, and technical issues, and they have a graduate program there. I was on the advisory board with them for a while until Covid hit, and we stopped having meetings. But it's broader than just running a load flow or designing a transmission line. It's got more impact than that to society in general. And I think it's important and for people realize the importance of it. And it's certainly a field that continues to have new and changing challenges. So, I would highly <laugh> recommend it to anybody who's in college who wants to pursue a career.

Julie Cohn (01:32:12):

Thank you so much. We really appreciate your time and your contribution to our project. And we'll be looking forward to following what you do next.

[End of Interview]