Algorithms & Power Systems Architecture:

Using Historical Analysis to Envision a Sustainable Future

Oral History Project

Interviewee: Mark Lauby

Interview Date: July 18, 2023

Place: Hyatt Regency Orlando, Orlando, Florida

Interviewer(s): Julie Cohn, Sairaj Dhople, Daniel Molzahn, Rachel Harris

Transcriber: Temi online

Keywords: Mark Lauby, Northern States Power, Midwest Reliability Organization, University of Minnesota, contingency analysis, Electric Power Research Institute (EPRI), power system planning, Prabha Kundur, stability analysis, expert systems, North American Electric Reliability Corporation (NERC), reliability, standards, Generating Availability Data System (GADS), Bruce Wollenberg, computers, Roy Billinton, Loss of Load Probability (LOLP), geomagnetic disturbance, Federal Energy Regulatory Commission (FERC), transfer capability study, cybersecurity, Energy Policy Act of 2005, Vladimir Brandwajn, inverter-based resources (IBR), energy.

***Abstract*:**

Mark Lauby is Senior Vice President and Chief Engineer at the North American Electric Reliability Corporation (NERC). He begins this interview by describing his education and industry training and his professional positions in Minnesota, at EPRI, at NERC, and overseas. His early work with Prabha Kunder addressed small and large signal stability and expert systems. His portfolio at NERC includes reliability assessments, transmission outage analysis, situational awareness, inverter-based resources, and cyber security. He discusses the value of collaboration across the industry. He describes continency analysis during the years before adequate computer storage was available. He explains the 1-day -in-10-year Loss of Load Probability used to analyze systems and speculates that future reliability challenges will have to embrace energy availability, weather conditions, and asynchronous generation, as well as shortfalls in transmission. He discusses geomagnetic disturbances. He explains FERC orders that affect NERC research priorities and the mechanisms for funding research. He speculates about how reduced university funding

for power system analysis research will affect the industry. He discusses the origins of NERC and EPRI, tracing influences from the 1965 blackout to the 2005 Energy Policy Act. He describes the effects of events, such as recent winter storms, on industry change. He explains NERC's efforts to inform policy makers about power systems. He reflects on Prabha Kunder's seminal book, now on bookshelves around the world. He explains his work on expert systems and compares it to today's AI and machine learning. He emphasizes that the industry's accomplishments are understated because we don't know what we have avoided. At the end of the interview, he returns to his work on contingency analysis and the scenario planning anticipated in the future, which will require the ability to analyze enormous quantities of data.

Note regarding Transcript and Timestamps:

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

Transcript:

Julie Cohn (00:00):

This is Julie Cohn. I'm conducting an interview with Mark Lauby on Tuesday, July 18, 2023, at the Hyatt Regency Orlando in Orlando, Florida. Sairaj Dhople, Rachel Harris, and Daniel Molzahn will be assisting with the interview, as will Sutanwi Chatterjee and Mahbubul Bhuiyan. During today's interview. We're especially interested in your work experience—first as a power system planner, and then as a regulator—and how companies and grid operators integrated control and optimization approaches into their operations. We'll begin with some introductory questions and general background information about you. So, if you would be so kind, please describe your educational background and your professional positions in the field of power systems.

Mark Lauby (01:42):

Sure. Started in 1979 as a student engineer at Northern States Power. They actually moved me over to the Midcon Area Power Pool, which is now called Midwest Reliability Organization. So, I started there in 1979 as a student engineer, and I thought, "Hey, I can do this." So, I spent my senior year at University of Minnesota getting power electives out of the way, and they hired me right out of school in June of 1980.

As I worked in—through the—went there and I did that for seven years. Mostly worked on transmission outage data, statistical analysis. We were really kind of gearing toward the idea of the one event in 10, except for transmission. So, we had an advanced program called PCAP, which was a contingency analysis program. And so, I did a lot of work in DC load flows and contingency selection.

(02:34):

I wrote a number of papers in this area. I wrote a number of papers and statistical analysis of relia—of transmission lines—so we could figure out what's the probability of a line going out versus a generator going out. And we've run what we call the composite reliability. During that 1980 - 1987, EPRI was also doing some work, Electric Power Research Institute, around that same time. Met a few people over there and they asked if I would be willing to join them. And I did so in 1987 and worked there for 20 years. Mostly in power system planning and operations as a project manager in a number of different areas. One was in power system stability. And I was fortunate enough to work with a guy named Prabha Kundur, who wrote the book early on reliability or on stability.

(03:27):

In fact, if you look in the forward, you'll see my name casually in there. I was able to convince him to write the book because he was teaching at the University of Toronto. And then of course was able to review that book over time. And that became quite a nice capstone for his career. We also did look at small signal stability along with local large signal stability. Did a lot of work in expert systems too at that time, as a project manager, and chaotic theory, also, of different things. And then over time EPRI was kind of going through its changes and they needed some folks to work with industry around some of their challenges. So that I became a technology application manager where I would meet with individual utilities, find out what their technical challenges were, put them together with EPRI research or, if it made sense, created projects around that research.

(04:21):

And then moved on to actually getting, becoming part of the business development arm. And then they actually spun us off in '92 to be a—EPRI international. And I led that effort to mostly have work in Asia,

but also in Europe with—lived at Brussels for a couple of years as we built out the business there. And then came back after a number of years. And I went back to the non-profit part of EPRI. But then I wasn't home a lot, and I was just starting a family. And so, my dad famously told me, if you wanted to have the children, you should stay home. So, I changed jobs and joined NERC in 19—, in 2007. And as a manager of reliability assessments and then, over time, standards development and all that. And I'm standing here now. Yeah.

Sairaj Dhople (05:17):

What is your current role with NERC?

Mark Lauby (05:19):

Well, I'm a chief engineer, senior vice president, chief engineer. And under my span of control is area work from reliability assessments where we assess reliability of the future systems. We're gathering data about the past performance, so that's transmission outages, the ADS tabs, all the—AD systems we call it. So, what's the reliability of the ongoing system? And now how's that trending? I have a group that looks at situational awareness from a widespread area throughout north America. Then I also had the engineering department. And that's where we're doing a lot of this work on inverter-based resources and making sure we can integrate them without them all going away when we need them. And a group that focuses on, now on cyber design, how do you, how do you robustly design cyber into your system so it's reliable when it's, when you get there. And then finally just the engineering department itself, which—anything from frequency response to registering to follow our standards. Basically, everything that's not a compliance and enforcement or ISAC, which is our cybersecurity kind of situational awareness group. And I don't have legal, of course. So—

Julie Cohn (06:36):

That's a pretty big portfolio.

Mark Lauby (06:38):

It's a blast. It really is. We've got a lot of things that are—we're facing—

Mark Lauby (06:42):

In Industry today. And how do we—and now of course, we had the Memorial Day surprise where the US government decided, the Congress decided to assign us a study of—unfunded mandate, in fact—to calculate the transfer capabilities across North America that was, came out of a budget, what they call it, the ceiling. They throw a paragraph in there for NERC to do something. So, yeah. So—but we're going to be doing—we're going to be obviously focusing on that over the next 18 months. The whole idea of the impact of weather now on our resource mix, and how do we make sure we get energy from where it is to where it ain't kind of followed a little bit about what, when I read your book too, about the kind of situation where we're talking about capacity, but energy, of course, changing all the time when you have changes and wind and solar and cloud cover. Too much clouds, too many little clouds. Excuse me. So, it's a fascinating time to be in the industry.

Julie Cohn (07:40):

Did the congressional requirement include Texas?

Mark Lauby (07:45):

Well, it's an interesting question. We will include Texas. They're, they're, we're right now deciding what they really meant. What does prudent mean? For example, what's the transfer capability today? Then what's prudent? And then how do you sustain that prudence? And so, I—they—we—when we talk to folks, are talking about maybe the FERC 1000 areas, but we just think that's not going to be granular enough. So, we'll definitely do what they ask us to do. We may go deeper. Texas, of course, is connected through its DC ties. Though there's a quote that describes how it was originally an AC-connected system. And the question is, well, how big can those DC ties get before they become interstate? And ask when the FERC—

Mark Lauby (08:31):

But we're not going to deal with that problem. What we're going to deal with is what is the need?

Julie Cohn (08:35):

Right.

Mark Lauby (08:36):

And then regulation is where it is, right?

Julie Cohn (08:38):

Yeah.

Mark Lauby (08:39):

And we submit that study to FERC in 18 months. Now 16. And FERC will then socialize that and then make their recommendations to Congress.

Julie Cohn (08:50):

Interesting. So—

Mark Lauby (08:52):

Yesh, it will be interesting. Yeah.

Julie Cohn (08:54):

So, would you characterize yourself as primarily in, I mean, you've been in research institutions?

Mark Lauby (09:02):

No.

Julie Cohn (09:02):

You've been in regulatory entities, I guess you were part of a system, system operator entity for—

Mark Lauby (09:11):

No. Well, MAPP was more a power pool.

Julie Cohn (09:13):

Oh, it was a power pool.

Mark Lauby (09:14):

Okay. Yeah. So, and that was kind of pre-regulatory days. So, it was like we'd have these rules of criteria that folks were supposed to follow. Remember that this came out of the '65 blackout, right. And the whole idea was, well, there's great charm and wonderful benefits to connecting, but there's risks. And so, we need these organizations like EPRI to do collaborative research, like NERC to bring organizations together, and the regional entities to talk about what are the regional criteria they should be following. Peer—it was peer enforced. If you didn't do it, then you get to the next meeting and I'd shake your finger at you and go, okay, I'll make sure I don't do it next time. Because that collaboration was so important. Yeah. As you pointed out in your book, this is one of the rare parts of the world where we developed this together through a disparate group of different types of utilities.

(10:00):

And so that really was the formation of that organization. But anyway, so I, that was power pooling, and I was gathering information about the past performance of the system so I could calculate statistics on

transmission outages. I would go to GADS, which is the generating availability system from NERC, and get that information, put that in a composite wide area program. But then there was some offshoots there about some of the work I did on contingency selection. I was fortunate to have Bruce Wollenberg as my advisor at the University of Minnesota who wrote that book on power generation, PGOC, Power Generation Operation Control, with Al Wood. He came across there and that, otherwise it was poor Ned Mohan, who kept on having to teach me about inverters, which I guess in the end helped out. It was a big deal now that he was doing motor controls back in the day. So yeah. So he was, he ended up being my thesis advisor. And I wrote my thesis on contingency selection, which is how do you identify the worst next contingency without actually running these simulations? That was a big deal because you didn't have the storage. Right. And we had Prime 400s at the time, which were kind of a minicomputer.

Julie Cohn (11:15):

Just to back up, when you say we didn't have the storage, you're referring to computer?

Mark Lauby (11:19):

Computer storage. Yes, exactly. That's why you had all this sparsity stuff and everything else. Right. So, in any event if you could identify the worst contingencies ahead of time, and I actually used a method that Zaborszky/Whang came up with at the University of, it was in St. Louis.

Sairaj Dhople (11:39)

Washington University St. Louis.

Mark Lauby (11:41)

Yeah, thank you. And where you had concentric relaxation, but I just simply froze two buses out, ran a Gauss, said, "Okay, voltage, this is going down there, that's easy. And then kind of line them up that way. So, running the whole thing. Anyway, that was, that was a lot of fun. And most—and if you look at some of the work, there's a lot of transmission outage data, out of— Worked a lot with Roy Billinton, Bob Ringlee, folks like that got the Billinton Award over the years.

Julie Cohn (12:18):

So, your work is, it sounds like your work really always has been at the intersection of technical problems, system, sort of conceptual technical problems, actual system operation, and regulatory requirements.

Mark Lauby (12:30):

Yeah. Over time. It certainly is regulatory requirements now.

Julie Cohn (12:34):

Yeah.

Mark Lauby (12:34):

So again, we help write the standards. We want to make sure when it comes to compliance with the auditing function, et cetera, but obviously those standards have to be based in ground and technical excellence. And so that's where we always try to be, no matter what the politics are. If you can get that technical engineering high road, then nobody can knock you off of that.

Julie Cohn (12:52):

Yeah. Yeah. So, what's the most important technical problem you've tackled right now?

Mark Lauby (12:58):

Oh, gee whiz. How about just the one today? Energy is a huge one.

(13:03):

We're used to—when I started in the business and I ran loss of load expectation calculations, it was what they called a copper sheet, which is basically infinite transmission generation with forced outage rates, which was one number instead of a distribution. Go figure out what your reserve margins would be if you had a—one event in 10. And that was pretty easy. Now and—

Julie Cohn (13:27):

And let me just back up again. For anybody who listens to this in the future, one in 10 is one event in 10 years.

Mark Lauby (13:36):

Right. That was kind of a frequency. It's not really a frequency, but the whole idea. And the reason why it was one event is because we only modeled one daily peak at the time. We didn't have these hourly peaks, again, storage computational capabilities. And so, this was, this considered as one event in 10, of course, that came, went back to Calabrese and Watchorn who came up with that in the forties, in fifties. And then after the blackout in '65, PJM said we should start building a system to this one event, 10 to make sense, because of—and they kind of became kind of part of our fiber almost across North America, maybe across the world. But that is not as sufficient anymore because you can have capacity based on—in a nameplate to be something.

(14:26):

But what you're actually getting out of it, is something else. And so that's why I call it the energy problem. Because that's an hourly change. And based on weather conditions. And now, how do you make sure that you have sufficient amount of energies with one event in 10? We are looking at capacity. And that capacity gave us, equals, energy plus essential reliability services, which in our things like frequency response, voltage support, ramping capability, we have standards at NERC all about those central, ancillary services, but not so much about energy. So that's one, one of the major challenges. And we've actually put into the, into the hopper, some standard development around energy. So that's, to me, like the big problem today. Along with, of course, the fact that we're going to have asynchronous loads and asynchronous generation, and somehow, we're going to have 60 hertz that's going to work in

the middle there, which is going to be really challenging, because you don't have inertia to slow things down unless you fake it. There's the real need for speed, for control. That whole synchronization's going to change. That problem's going to change, obviously. And we're going to need more transmission to get things from where they are to where they aren't. Yeah. Unless you have localized generation of hydrogen, and that's all not to scale yet. So that's another decade or so down the road probably.

Julie Cohn (15:52):

So, the energy problem is a new—would you describe that as a relatively recent problem?

Mark Lauby (16:26):

Yes.

Julie Cohn (16:27):

But still, if you look over the past, I can't count fast enough, 40 plus years of your professional career, it still stands out as the most difficult.

Mark Lauby (16:41):

Some of the other things that I was fortunate enough to work on around geomagnetic disturbances and putting that to bed. There was this view that with a GMD event you would lose 300 transformers across the country, and people would be in dire straits. The economy as we knew it because it takes decades to build this back. And we were able to show, with good modeling - that was not just me here. I mean, gosh, I, some brilliant people like Luis Martí and—part of the Martí Brothers, we used to call them José and Luis—that was working on this with us, and NOAA was working with us on it. And we were able to get to a point of understanding that that's not what's going to happen. Voltage collapse might happen. That's what happened in Hydro Quebec. Making sure we just put that whole myth to bed. And now we understand how to, and we have written standards on how to manage the geomagnetic disturbances we have in North America. That's certainly one that I'm very proud of. But again, took a lot of people, the—what you do at NERC and at MAPP and even at EPRI, is bring people together to convene and solve

problems. Right? And you bring some of the industry's best to work with you on that. That's the delight of working in those organizations because you get to work with some great people.

Julie Cohn (18:02):

Do you also, do you see collaboration with academic researchers as well?

Mark Lauby (18:07):

Yes. In fact, we, when we study problems like that, we'll bring, we'll ask researchers to join us, sometimes I need to pay a little bit for time. It isn't that much. It's mostly—I mean, it's mostly just getting their brains case on it. Yeah.

Julie Cohn (18:21):

Yeah. Is there—are you able to enlist federal funds from other sources to help?

Mark Lauby (18:30):

Well, let's just talk about how we get funded at NERC. And it's an interesting formula. It's based on net energy to load. Every consumer in North America, and many in Canada as well, helped pay for NERC. So as opposed to EPRI, which was based, kind of, on a program, and maybe an energy load or capacity or whatever else and was—you had to really go out and convince folks to spend money with you. At EPRI. At NERC is really a budgeting process, which is very public, is posted, comments received, we adjust as needed, and then we go to our board in August, and then they submit that budget to the Federal Energy Regulatory Commission, and then they pass on it. And then we have our budget for the following year. We've tried to make it a three-year look, but it's really one year through FERC. And so that's really where we get our funding from. And what's good about that is we can be then independent and objective. In fact, I think one of the reasons why we ended up in this transfer capability study is because other agencies are federally selected; leadership that's federally appointed.

Mark Lauby (19:42):

We are not. Our, our leader—. We have an independent board, which is made up of folks, and some of them have industry experience, some do not. They have no holdings on anything. And they help us identify who our CEO is going to be. And then, of course, management reports to that independent board. And so, taking money elsewhere, you do have some challenges, of course. You take federal money. It's, and the auditing and all, that's a bit painful, needless to say. And so, we don't really pursue a lot of outside funding. Now, there is some—groups, for example, EISAC, which is our cybersecurity situation awareness group—there is some separate funding that comes from utilities that actually put on their system these appliances that monitor traffic. And then they become a clearinghouse of information around: has there been any kind of vulnerabilities identified, any potential attacks, and how we're solving those problems and all that. But otherwise, we're basically funded through the public, through distribution. We go to basically distribution companies, and they send it to us through the net-energy-load.

Julie Cohn (20:51):

So, it's on our power bills, whether we know it or not.

Mark Lauby (20:54):

It is. You pay about 28 cents a year per family. Okay. Which we think is a cheap insurance policy.

Julie Cohn (21:00):

I had another perspective on that I was trying, I don't think I framed the question well though. But, so let's say the geomagnetic disturbances concern—because you needed input from academic researchers, industry, NOAA, others—would it be the case that NERC might go to the Department of Energy and say, "We want you to fund some universities to research this if you can fit it in your budget?" Or is that, like, outside the scope of what you do?

Mark Lauby (21:32):

We worked with the Department of Energy to fund government support, suggest funding, help them identify some priorities.

Mark Lauby (21:40):

But in this case, we also then funded some of that research ourselves. We funded research through the Electric Power Research Institute or EPRI. We also had a couple of universities that we funded. It really depends on the program, but if it's, especially if it's cutting edge, and yeah, it's coming into our face, then we will bring forward some of the industry experts. And some, some will volunteer through electric utilities. Some are funded through other utilities. And we will fund research. We fund PSERC every year, so we try to stay on cutting edge.

Julie Cohn (22:14):

So, do you see that kind of multi-sector collaboration to address a defined power systems problem? Has the approach to that changed over time? Like, if you look back at your, the first decade or so of your career?

Mark Lauby (22:31):

You mean in the 1980s?

Julie Cohn (22:35):

Yeah. '80s, '90s.

Mark Lauby (22:35):

I think I would say that the electric industry and the, in the ‘80s, prior to the deregulation, shall we call it, of the industry, they were, they perhaps didn't spend enough money in research, but it was more consistent. When I joined EPRI, every company sent money to EPRI and we didn't define where we were

going to spend it. Then it became much more program specific. When you have a generating company who doesn't want to fund transmission research. At the time, it was what helps one, helps us all.

Julie Cohn (23:09):

Right.

Mark Lauby (23:09):

That attitude was changed during the 1990s when, when we went through this kind of, I'll call it delamination in certain parts of the United States. And so EPRI had, of course, change its research programs accordingly. So, I think it did change that way. But I think other than that just working with uni- and I am concerned about is there enough research being done with the universities? because that's their blood.

(23:37):

And if not enough, research is going on in power system analysis or power systems, then the professorships dry up. And we can talk a lot hard around the need for cross-people in this business, across all different types of specialties and list the craft workers. When we're looking at building out a system that's going to have three times the load it has now, based on the electrification forecast, and residential, commercial, industrial, and meanwhile having to build generation to meet that need and transmission, we're going to need a lot of people climbing poles and building stuff and doing analysis. So, it's a—I think it's a great career and we just got to make sure we have the people there. Yeah.

Sairaj Dhople (24:26):

Mark, can you tell us a little bit about the two organizations that you've been in a part of, like, something about how EPRI got started and something about how NERC got started?

Mark Lauby (24:35):

Yeah. I think they were all come rooted in the same time period, in the 1965 blackout. And at the time, as I said before there was—there's identification of a risk that the interconnection created, even though there were great rewards. And the industry was trying to take—kind of stay a step ahead of the federal government, because the federal government was thinking about, well, maybe we should regulate interstate and write regulations, and we should fund research through our labs. And industry said, "Now, wait a second here, show us [so] that we can do that ourselves." And that's—I think it was a—I want to say a blue-ribbon panel or something. Anyway, there was a report that came out that established this need for collaborative research to study problems and solve problems around reliability.

(25:29):

And then, of course, an organization around operations and eventually then planning. So those were coordinated. So, you knew what your neighbor was going to do. So, I think that had a lot to do with the, that some of the industry leaders at the time, CEOs, the, some of the largest power companies in North America got together. And actually, a lot of this work also was very collaborative with Canada, especially in Ontario, but then also in Vancouver or British Columbia and Quebec. I think that was really kind of the that, and holding, this idea of holding each other hostage, you might say. But then what I do on my system impacts your system. So, we need to work together if we're going to be staying interconnected, anyway, to take advantage of those benefits.

(26:20):

So, I think that was the history of the two organizations and I kind of felt fortunate that I kind of worked for both of those types of organizations. The MAPP, which was the power pool, one of the regional entities that reported information to NERC back in the ‘80s, and then, of course, EPRI itself. So, I think that's—and of course, EPRI's gone through its changes. Obviously, NERC has the idea of this delamination of the industry into, into markets. It drove the need to ask the question: who owns reliability? Is it the generator? If you have a blackout, is it a generator's fault? Is it a transmission company's fault? Used to be able to say, "That utility there," but now you have this, kind of, “who owns what?” And so, there was a lot of conversation around that in the ‘90s.

(27:11):

And then a view, another blue-ribbon panel that said, "We need to start establishing standards." And in fact, Ontario started establishing standards that they had to follow and were enforceable. And then after the 2003 blackout, that kind of kicked it in the shins, and then they moved it into 2005's—the Energy Policy Act of 2005—where they called for an energy reliability, Electric Reliability Organization, or ERO. And then that led to the pathway of NERC then submitting to be that organization. A group of about 20 people. And now we're around 240. We were selected to do that in 2006. And then I got hired in 2007. So, it really changed the face of that organization to be much more—it used to be much more regionally focused, and now it's much more North American focused.

Sairaj Dhople (28:05):

Do you see that big changes in the power industry only come after big events?

Mark Lauby (28:12):

Well, it seems to be a certain energizing for the industry. I don't want to be feckless. I mean, if we see what happens, for example, in Texas where you have 200 people that die as a result of not having electric power. And I look at that, and even though there was no standards violated, is that really where we want to be? No, we don't want to be there. So, we try to lead, we try to get in front of—but it does seem to take a few of these kinds of cold events. In 2011, there was one in 2014, with one in 2018. We're out there saying we've got to be writing standards, we've got guidelines, are you following them? No, not really. And we find out during events they're not following them. So, to keep—the only way we can keep the conversation going is through standards, it seems, because then they have to follow them all the time. But it does seem to take some of that. I think that there's, I'd like to think there's leadership in the industry that's helping us push forward in this, certainly this energy arena. And it's something I think that NERC can do is lead by bringing together experts and that and focusing on key issues.

Julie Cohn (29:32):

Is the, do you see the leadership currently coming more from the vertically integrated corporations than from the—like the generating community or transmission-owner community?

Mark Lauby (29:46):

I think, I think it's in two places. We're seeing certainly the, I think that the traditional vertically integrated organizations, but also, I think we're seeing some very unique innovations at the ISO/RTO level. And of course, that's kind of been in their lifeblood because they've had to—you develop innovative marketing and products. And so, I just want to be able to work with folks like Gordon Van Welie over at ISO New England, for example, when they get an award tonight for his work. There are, there are folks like that in the industry, in the actual RTO community, that are really looking forward and saying, this is where we are, this is where it's going. We have to be able to sustain long-term investment in markets, are we situated to do that? We need to be able to build transmission between markets.

(30:37):

Are we willing to do that? Doesn't it remind you of what happened back when the investor owns it? I don't really want to compete with my neighbor. But we need to start thinking about that, especially when we have to move energy long distances, because we are seeing widespread, long-duration weather that impacts our resource availability. And that may be a spinoff of climate change. This kind of weather, cold versus hot. I don't know. I do know that we are seeing a, appears to be a higher frequency and the extremes are, are larger. So, history doesn't tell us or inform us very well about the future.

Daniel Molzahn (31:18):

I had a question about the leadership discussion. So, you sort of made it sound a bit earlier that Congress sort of slipped in this paragraph into the budget. Now you guys are doing these transfer capacity studies. How much did, does NERC and FERC and EPRI and ISOs, who's kind of communicating with Congress or with the other policy makers to make sure that they're going to, when they ask you to do things, they're reasonable things to do and that they're writing good policy?

Mark Lauby (31:48):

Sure. We have a group in Washington DC that certainly represents our, our interests. You might say we don't lobby per se, but we do inform. We feel that our reports inform. They are long-term reliability assessments, the summer assessments, and our state of reliability reports. They are all reports that we think inform policy makers. We're spending more time though, not only with the federal organizations, but also with the states, because they're the ones that through 215, which is the Energy, Power Act of 2005, states have the right and can, are the only ones that can order the construction of capacity transmission or generation. So, we need to have that conversation with them, so they understand what the implications are. If they do nothing if they just leave it to the market, what might happen they are responsible for—to ensure a sufficient amount of resources there to meet their state's needs.

(32:51):

So, we are also having conversations with the states as well. So, we—and we do that through our regional entities. And there are six regional entities. One in Minneapolis, New York, SERC, which is in Charlotte, one in Texas of course, and then one in Salt Lake City. And they work with the states as well, and of course we support them. And so that's been a major ongoing initiative, because it's information. When people are making policy decisions, they may not be engineers—probably better that they're not—but policy needs to be informed by the engineering capability. Sometimes you look at things as how are we going to get there. And sometimes it's—policies—aspirational, and, as you know—that we're doing the best we can to get there. And maybe we'll make some adjustments down the road.

(33:42):

But we do spend quite a bit of time. That being said, I mean, they know who we are, but on the other hand, the time behind closed doors, what they make, the decisions they make, they're going to make. Right? But, and FERC itself too, they're—they've got ongoing discussions internally there about reliability among other things. They have a rather large portfolio. And when it comes to reliability, they can order us to write standards as they did here recently. At the same time that the study came out, they ordered us also to write transmission standards around weather and the impacts of weather on transmission. It's all about avoiding the evil three. Called the evil three. Cascading and instability and uncontrolled islanding. And we don't like that. That's a bad thing. So how do we build a system so that during certain weather patterns, that we don't get ourselves in that position.

(34:34):

It used to be like the end, with a line-to-ground fault, the stuck breaker. You have to be stable when that happens. Similarly, now, we—I call that kind of like the design basis of the system. And we need to be thinking about it from a weather perspective as well as cyber. How do we, what is the, what's the level in which we're going to build to? That's so-called normal operations. And then of course the trapezoid. Of, well, okay, we're going to try to control how bad it gets, and then how do we recover and make sure we study those extreme events, so we know how to recover from that. So, it's a similar type of idea with, I think, with weather and transmissions or cyber. And now we're going to do the same thing with energy. And so, I can't order construction of transmission and generation capacity, but an output is energy. And that's something I think I need to be able to regulate. Yeah.

Julie Cohn (35:28):

Did you want to circle back to any of the technical problems that Mark raised as topics for some of his work?

Mark Lauby (35:38):

One of, some of the areas I think that we need to be starting to refocus on, surprisingly, is the ability to model three phases, especially for inverters, because we're seeing inverters with a simple line-to-ground fault disappearing, saying, "Goodbye, I'm not going to hang around to support the reliable operation of the system." We have to model three phases to do that. And I, and I caught the engineers that come out of their undergraduate programs, and they said they can't do it. I still have my 22 out of 25 from Ned Mohan on my SSR study. I got it right on my desk. I'm so proud of that. But it was a master's program. But—so I think that's one of the challenges that we need to come back to. Some of the traditional modeling is going to work for us there, just like we had the one event in 10.

(36:26):

I think that this interconnection. Small signal stability, as we add more and more controls on the system, I think there's going to be—all the poles on the righthand side of the plane, remember, the plane crashes, that's the whole story. You had to be from Wisconsin to really enjoy that joke. But the whole idea of making sure that the controls we are putting in place are stable as we add more and more controls in the system. And then cyber design, critical piece of the system and future make sure that we are less vulnerable. And that may mean supply chain, and bring, shorten that supply chain up. So, it's in the US but also just making sure that we do it in a wise way. And so, some of those problems that we, that we thought we had handled back in the small signal stability days and voltage stability days, raise their head up occasionally. It's basic engineering as we go through this transformation that we need to kind of come back and revisit. Nevertheless, synchronization, right?

Julie Cohn (37:25):

So, I am going to take you back in time again to the Kundur book. You said you persuaded him to—

Mark Lauby (37:33):

Yeah. That's a kind of a story on its own. Prabha and I used to—we became good friends. He was actually best man at my wedding. And good friends in Toronto, while he was at Ontario Hydro and we were funding some research there and with him. And anyway, so one of the things that EPRI wanted to do is, they developed a series of books that would be taught in schools. And that folks then—that the idea was, well—then these young professionals would've heard of EPRI, think EPRI's a great, good place and would continue thinking about funding it after they left the university. So that was kind of the philosophy.

Sairaj Dhople (38:13):

The book does say "EPRI" on the side.

Mark Lauby (38:14):

Yeah, it does. And of course, the current version doesn't, this group came out with another version, which was another story I want to get into. But yes, it did, it was a part of every series there. Two books. One came from Carson Taylor; I convinced him to write that book on voltage stability. I'd love to get a copy of it. But on eBay it's like three hundred bucks. And then Prabha's book and Prabha spent many nights and evenings putting that book together. EPRI kind of funded some of that work, I would review the chapters when it came out so I could learn something. And he spent, spent a couple years putting it together. And then of course after he, then he went to Power Tech over at Vancouver and, as a subsidiary of BC Hydro, headed that organization up. And I worked with him quite a bit there too, because when I was in Asia, finding some work, with contracts, and I worked with Power Tech. And then he—when he retired, he went back to Toronto. And his daughter is heavily involved with power systems too. She was at Texas A & M—in College Station?

Julie Cohn (39:21):

Yeah.

Mark Lauby (39:21):

Is that Texas?

Julie Cohn (39:21):

Yeah.

Mark Lauby (39:22):

I don't want to get in trouble. I have my—my niece worked at University of Texas.

Julie Cohn (39:28):

Oh. Yeah. That is a problem.

Mark Lauby (39:29):

But anyway, now she's back in Toronto too, at U of T. She's the dean of engineering over there. There's a lot of cyber work on power systems.

Julie Cohn (39:37):

So was the book primarily his own work or was he compiling decades of—

Mark Lauby (39:43):

It's his work. He did ask some for help from a few folks like Le Wang and I'm trying to remember some of the other names that helped him, for example, put the graphics together. You got to remember back in the day—if you look at some of my papers—we used to take a big blue sheet. And we'd paste the columns down and we'd hand draw maps.

Julie Cohn (40:05):

Yes.

Mark Lauby (40:05):

And all that and glue them on the map sheet. I just recently surfaced a few of my old papers because I actually wrote papers on transfer capability. So, I've been sending over the crew this for a heck of it. But—and so that was—a lot of that was kind of done by hand until at least maybe McGraw was able to come up with their own. But it was his work based on courses he was teaching at the U of T.

Julie Cohn (40:29):

Oh, okay.

Mark Lauby (40:30):

Over the years. And that's why I convinced. I said, "You already have the notes."

Julie Cohn (40:34):

Yeah.

Mark Lauby (40:34):

I got to just put the words around it.

Julie Cohn (40:36):

Yeah. And somebody here was talking about that book on their desk recently, correct? Yes.

Mark Lauby (40:42):

I got two of mine.

Julie Cohn (40:44):

So, it's still—

Mark Lauby (40:45):

Yeah, he spent his—after he retired, he spent his retiring years going around the world teaching from that book.

Julie Cohn (40:52):

Oh.

Mark Lauby (40:53):

We had him actually come into NERC one time too. Classes of about 30. He'd want real big classes. And then you'd get a copy of his book he, that he would sign. And then he would put these courses on. Many times, in Europe, Latin America, and Asia. I'd go around the world, and I'd see his book up on shelves everywhere. Yeah. Yeah.

Julie Cohn (41:13):

Interesting. So, any other technical project topics we want to explore?

Daniel Molzahn (41:21):

Well, one that I had, that you, you sort of very briefly mentioned this, and I was curious to get your opinion is, you mentioned expert systems. Before my time, but I have heard stories about how expert systems was seen as this very kind of popular emerging idea in the eighties. It was, kind of collapsed as a topic. And I wonder if there's, if, if you could maybe talk about that a little bit more?

Mark Lauby (41:42)

Sure.

Daniel Molzahn (41:22)

Maybe any analogies to this data driven work today.

Mark Lauby (41:45):

Yeah, well, AI, that's an interesting issue altogether. Bruce Wollenberg one time told me about AI, but I'll hold my fire on that. But that the expert system program that I was working on initially was one on

relaying. And it was really around kind of identifying how to minimize the amount of switching you had to do. And the professor who was working at that, at—University of Washington's in Seattle, right?

Daniel Molzahn (42:19):

Yeah.

Mark Lauby (42:19):

It was Chen-Ching Liu. And he was using expert systems as a way to minimize the impact on the consumers and bringing them back much quicker. And I think that they tested that in a number of different locations. And so, he and I wrote a few papers on expert systems at that time. And I think it ended up being, well, what's the difference between that and just writing FORTRAN code? And that's just how old I am or new code, whatever they call it, Python nowadays, I guess. But writing just kind of a logical. I think that's kind of where there was a lot of machine learning. And I don't know if we call it expert systems in load forecasting? Right? Which I think still, people use a lot though, the worry is, again, history, and the future is that kind of—we—you heard about the, the, a couple cold spells where forecasting was way off.

Daniel Molzahn (43:17):

Right.

Mark Lauby (43:17):

And we don't know if that was way off because the—what they call heat pumps become resistant heat after below 20 degrees. And so, then it goes way up. Or if there are other things we're missing in that forecast—that loads, awkward, certainly different. It wasn't—what did Box say, from Box-Jenkins? He said that "All models are wrong, some are useful." Right? And so, I don't think some of these models are as useful as they used to be, so it's something we might want to revisit. Yeah. But now, if you look forward—machine learning, AI—if we get, if we peel back all the scary stuff, and an industry that says, "Please regulate me because I don't want to regulate myself"—When you think of big gobs of data,

trawling through and looking for trends, it's intriguing. And one thing we're getting more and more in the power system is data.

(44:17):

Lots of data, too much data. So how do we start trawling through that and start looking for trends for maybe equipment that may be on the edge of failing? Is there something there or asset management? Just getting beyond the scary parts and seeing where the applications are. We're inter-, we're intrigued by it, but we know, I don't know if there's a lot of people experimenting with it, but where it's going to land? It's still an exploratory stage in my opinion. Yeah. It still is. And again, it's a matter of making sure also that we're really comfortable where the code come from. For example, I don't know if we know it, but we had this thing called the Owl, and you go in a room and you have this meeting, something, this is great, I got zooms around the room. And so, then we went and found out where they were getting their downloads from. China. Said, oh, well that aside, so we've talked. When it comes to some of the coding, we have to make sure that we're comfortable with the safety of what we're using. But yeah, it seems like a powerful potential tool. Yeah.

Rachel Harris (45:24):

I have one more question. You had mentioned the 1965 blackout and, as sort of a turning point for the power systems community.

Mark Lauby (45:33):

Yeah.

Rachel Harris (45:33):

And I think people we've interviewed previously have also referenced this, and I understand that was really before your time as an engineer, but—

Mark Lauby (45:40):

But it was not before my time, I had a grandmother in Brooklyn.

Rachel Harris (45:45):

Okay. Just—could you elaborate a little more on the impact it had on the community and what new algorithms were developed as a result of that blackout?

Mark Lauby (45:53):

You got to think about when it happened too. The 1960s and all the—IBM bet the farm on their 360. The IBM computers were coming up. So, trying more computers, UNIVAC and a few of the other kind, they call them digital twins nowadays. Used to just call them simulation codes. But the tools that you could use, and of course the transition, I think you mentioned in your book from the TNA, the Transit Network Analyzer, to coding it and what are some of the strengths and weaknesses of both? Maybe you want to have a little bit of both going on at the same time. So that was all happening around the same time. I think it was traumatic for the industry. An industry that—I keep on referring to your book, but it's true—that was very proud of what they'd been able to accomplish through World War II, the Korean War.

(46:41):

And pulling the country together, we had gone through the electrification of the country, thanks to FDR, and the co-ops, and to rural electrification, to federal agencies stepping in, to Muni's stepping in. So, an industry was very proud of what it was able to do. And I think perhaps too proud because then that can lead you to bias and mistakes. And so, there was a kind of a view that nothing could go wrong here. Had some issues around some relaying, as you know. And so that was a traumatic experience. And I think the public finally woke up and said, "Hey, what's going on here? I just turned the light on, now all of a sudden that's not working."

(47:29):

And it was a scary thing, certainly at the time, in 1960s in New York City going dark, because of all the other things that the country was going through at the time. And so, I think a lot of that kind of put paid to study work, what happened, Congress acting, industry acting, and so it was just a traumatic time for the industry, and they really wanted to get it back on solid footing. Now we've had, we've had blips, we've had other outages too. We've had issues in Texas. So, does it always take a serious event? I hope not. I wonder how many events we have avoided. And that's, that's the—there's a famous relay guy, I think his name was Blackburn, and I went to a relay course with him, I think at Virginia Tech.

(48:19):

It was one of those short courses. And he said—he was a stern man, and he rapped on the table—and he said, "Nobody ever called me at 3:00 AM in the morning and said, 'The relay worked.'" And so, we don't really know how many we've avoided. We know the ones we've had, and certainly they have stirred action. But I think that was the most traumatic because it—even though we'd had some other kind of blackish things in the past, it was that one seemed to catch the eye of the press and was one of the more serious blackouts we've had until recently. I think that's very—what it—kind of drove it.

Daniel Molzahn (48:58):

One other technical question, back to something you had mentioned in the beginning. So, you said you started working at Minnesota on your contingency selection, ranking, and screening. Do you know how much of the methodologies that are used today for those purposes are similar or different to the—?

Mark Lauby (49:15):

I mean, that's a good question. I don't know. I—the reason why I don't know is because I've moved on. When I left NERC and I went to EPRI, I developed some friendships with a few folks and continued that work. Vladimir Brandwajn who works at Systems Control. And now I think that's, that was Systems Control at the time, and I lost track as it, is it Siemens now? I'm not sure. He and I wrote a number of papers on contingency selection, and he was really good at the matrix. But I worked also with Sherman Chan over there as well. Of course he was more of the short circuit guy, but—so I think that some of that work is embedded in some of the energy management systems.

(50:01):

But the thing is—one of the—as you see your life and the work that you've done, sometimes things supersede it. So now your phone, you can run contingency selection. So why waste your time going through that process when you can just go run them off? So, we'll see. We'll have to see if going deeper is going to make a big difference. I remember working with a guy named Jim Van Ness, and he was doing, he was going through the parallel processing idea of the—and I think that's what a lot of folks do nowadays is they just run them all. So maybe my work has gotten—been outdated there.

Daniel Molzahn (50:45):

Well, I guess the reason I—one of the reasons I wonder going forward is if we have to simulate lots more scenarios with uncertain renewables and looking at contingencies—

Mark Lauby (50:54):

I think you make—you make a very good point. And what I've been talking to folks is that with scenario planning, it explodes. The amount of things that you need to study. It used to be, it was this, who cares care if blue, 50-50 blue, every day is a blue-sky day. And it didn't impact your generating mix. I mean, the change—the difference between the disaster around your resources versus your transmission is significant. If you have a tornado come in, you call your neighbor, they all come together and they rewire the system. When it's, when it's cold out and you can't get gas. And that's another problem by the way, getting the gas industry to start following reliability standards, we haven't gotten there, so that you can count on them. You, your neighbor's not going to be able to help you unless you got transmission to come in and maybe they can send it too. But if they're experiencing the same problem, you are, you got to go even longer distance to get to the power into your area. So mutual assistance doesn't work as well in some of those cases. Yeah.

Julie Cohn (51:53):

Well, I think we've—

Mark Lauby (51:54):

I could talk for another hour.

Julie Cohn (51:56):

—taken an hour of your time, which we greatly appreciate.

Mark Lauby (51:59):

No, not at all. It's been a real pleasure to have a chance to meet you.

Julie Cohn (52:02):

Oh, thank you.

Mark Lauby (52:03):

Thank you for the book and keeping the lights on.

Julie Cohn (52:05):

Oh, sure.

Mark Lauby (52:06):

Nice to meet you in person, because Jeannine has mentioned you.

Daniel Molzahn (52:09):

Oh, that's, that's great. Yeah. I really enjoyed having her in class.

Mark Lauby (52:12):

And of course, University of Minnesota. Go Gophers! <laughter> We like rodents, don't we? Started at University of Wisconsin, moved over, one rodent to the next. It's been a real pleasure.

Julie Cohn (52:24):

Thank you. Really greatly appreciate it.

Mark Lauby (52:25):

Yeah, thank you. And if there are any other questions or whatever else you'd be happy to—thank you.

[End of interview]