Algorithms & Power Systems Architecture:

Using Historical Analysis to Envision a Sustainable Future

Oral History Project

Interviewee: Bernard Lesieutre

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Abstract:

Dr. Bernard Lesieutre (Bernie) describes his academic training and career in power systems analysis. Noting his move from computer engineering to power systems engineering stating “motors are the coolest thing ever.” He explains that his work on load modeling has likely had the biggest impact on the industry. He describes notable blackouts in the early 1990s attributable to voltage collapse and his

follow-on work to model, understand, and prevent voltage collapses. He mentions an anomaly when corrective actions to restore voltage actually exacerbate the problem. He names colleagues in the United States and Europe who worked on the problem at this same time. He explains that addressing voltage collapse was the “hot topic” of its time. He underscores that fear of blackouts drove interest I these models. He mentions industry collaborators in this research. He discusses the challenge for academic researchers to collect data for developing and validating models. He describes one of the more challenging technical problems he tackled – a series of small faults during summers in California that were evidently triggered by air conditioners with reciprocating compressors. Southern California Edison, Bonneville Power Administration, and the Electric Power Research Institute (EPRI), provided test facilities for this work. He notes that the resulting models are integrated into software still in use today. He mentions the refurbishing done by Bonneville Power Administration for the testing work, necessary to create a room that could run the air conditioning units. He mentions other types of loads modeled and tested. Dr. Lesieutre discusses his most-cited paper on DC-to-DC converters. He mentions his background in Russian mathematics applied to averaging as useful for the project. He describes power electronics as potentially “bad loads” depending upon how they are programmed. He explains the process for reaching consensus on standard models adopted by groups like the WECC and by software vendors such as Power World. He describes how utilities and system operators use the resulting models. With regard to involvement in public policy development, he mentions the Energy Policy Act of 2005, which conferred authority on the Federal Energy Regulatory Commission (FERC) to assure reliability on the Bulk Power System (BPS). He and his colleague, Chris DeMarco, offered a methodology for defining the BPS, ultimately not adopted by FERC. He contrasts the traditional rule-of-them that uses absolutely transmission rating to differentiate between the BPS and distribution systems with his proposed system of ranking of most to least important devices on a power system. He discusses his more theoretical and fun papers, including work on financial transmission rights, noting that flaws he identified twenty years ago are still in place today. He mentions the loop flow problem at Lake Erie, and his “influence model.” He notes that there are cases of power system innovation influencing computer science innovation, giving the example of sparsity techniques. Looking ahead he speculates on the role of renewables and nuclear fusion on the grid. He reflects on his experiences with high profile engineers while he was a student at the University of Illinois. He closes with advice to newly minted engineers to stick with the basics and stand by their engineering results while learning about the real-world applications where they will be used.

Note regarding Transcript and Timestamps:

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

Transcript:

Julie Cohn ([00:00:02](00:00:02)):

This is Julie Cohn. I'm conducting an interview with Bernard Lesieutre on July 25th, 2025, at the University of Wisconsin-Madison. Daniel Molzahn is here in the room and will assist with the interview and Sairaj Dhople has joined us via Zoom and will also be asking questions. There are a number of other guests in the room, and some of them may join in the interview later in the process. During today's interview, we're especially interested in your early work on power system modeling, load flows, and optimization, and how this later was carried forward into industry application. We're also interested in your work at the nexus of engineering and public policy and hope to learn more about that. But first we'd like to begin with some information about you personally, your background, your academic training, and your professional trajectory.

Bernard Lesieutre (00:01:29):

Alright. Bernie Lesieutre. I, like Sairaj, am a graduate of the University of Illinois. Did all my degrees there. Spent 10 years in Champaign/Urbana. Let's see, what can I say about that? I started as a computer engineer and then moved to power systems after taking a course that was in a list of a breadth requirement for undergrads. Take three courses out of a list of five, and I took one on electromechanical energy conversion and thought motors were the coolest thing ever. So, I switched, and they are the coolest thing ever. Motors are the coolest thing ever. So, stayed around for graduate school, got a PhD from Illinois, did research on load modeling, which I continue to this day and might be where I've made a bigger impact than other things. Yeah. So, that's my academic background. Been in academia most of my life. First job out of college was professor at MIT. Then I went and worked at a National Lab. So, I worked at Lawrence Berkeley National Lab. Then came here. And I've been here for 18, 19 years now.

Julie Cohn (00:02:42):

Thank you. And what would you consider your most important technical contribution to the power grid over the course of your work?

Bernard Lesieutre (00:02:54):

Well, that's a funny thing. So, it's probably the load modeling, and I'll explain that, but it's not the stuff I like the most. My most—proudest ones are the papers that you write that are theoretical and only six people read. Those are, those are fun. But the load modeling probably has the most impact. So, load modeling is, the power grid is immense. It's a machine operating on a continental scale. So, it's all connected. You know, the wires leaving this building connect to other wires that connect to other wires that connect to Boston, to Atlanta. It's—the whole thing is connected. And operating that system. It's amazing. It works and it usually does. But to model that, engineers need to know how the components work. And at the generation scale, we know how components work. They're just components. We can measure them; we can model them from basic principles of physics and know how they work.

Bernard Lesieutre (00:03:54):

Transmission lines are just wire. Transmission engineers will probably think that's a bit dismissive, but they're just pieces of wire just strung across the country. And we can model those and understand how they work. But when we get down to the load, that's representing parts of cities or entire cities or neighborhoods, and it's just too complicated. So, we have to come up with models that we use in our power grid studies that will represent how those components, in aggregate, will react to disturbances in the grid. Or how they might act to create disturbances in the grid. So, when I started this, the big thing we were worried about was voltage collapse. At the time, in the early '90s, voltage collapse was a new topic, or late '80s, late '80s and early '90s. They had witnessed these disturbances around the world, in Japan, and in probably someplace around here. There were very notable blackouts, and I think France and Japan, where they just watched the system collapse, the voltage kept dropping.

Bernard Lesieutre (00:04:59):

They thought they were doing the right things to correct it, but it just made it worse. And then the system just went down. They had blackouts. And so, it was a slow phenomenon. It wasn't a vast dynamic phenomenon that we had studied up to that point. And it was a load-driven phenomena in part. So, the characteristics of the load mattered. And so, that's how I got into it. We were studying load models to try to understand voltage collapse and this phenomenon. And so, that was a big topic in the late '80s and early to mid '90s. And people still talk about it and study it. And Dan and I even published a paper on studying voltage collapse point. And it's still a common topic, but now at least it's understood. And back then it wasn't clear the model existed even reproduce these things.

Julie Cohn (00:05:50):

Had there not been significant voltage collapse events prior to the 1980s?

Bernard Lesieutre (00:05:58):

Possibly, but not known. I mean, we don't notice everything, in fact. Possible. But it really did hit the headlines in the, in the 1980s when there were these blackouts.

Julie Cohn (00:06:12):

So, that opened up a new field of research.

Bernard Lesieutre (00:06:15):

Yep, it did. And so, a number of people go to the IREC conferences. That initially started with looking at these type of phenomena. So, I don't think I went to the first one. I think I went to the second one or maybe the third, I don't know, early on. They even created this conference to look at these emerging phenomena. Yeah. So, it was, it was new.

Julie Cohn (00:06:41):

Was the physics understood but the model not developed? Or was it also a question of learning about the physical phenomenon behind it?

Bernard Lesieutre (00:06:51):

The physical phenomenon was hypothesized. I don't know that it was known to be true. Fairly early on, I guess. Yeah. But there were some surprises. So, we have these famous power voltage curves and if you increase the power demand and the voltage normally drops and decreases, and you reach some point where you can't move power past the point—point of maximum power transfer. We teach that to undergraduates. It's a very, very well-known thing. But they were reaching this point, and it was a slow phenomenon. There are also very, very few cases where it was the opposite. So, we have this power voltage curve, but it's not unique. You can have low voltage solutions and high voltage solutions. And there were some cases where people were operating on the low voltage solution. And in that case, the corrective actions you take do the opposite of what you think they do, and it actually makes things worse. And so, there were some instances of people claiming that they've seen that happen. And I've seen people present compelling data that that actually did happen.

Julie Cohn (00:08:00):

Did, did your focus on this begin with your graduate work or after?

Bernard Lesieutre (00:08:04):

Graduate work. I think my first, no, my first paper was in power electronics. My second paper was in power systems and looking at these power voltage curves—dynamic aspects of PV curves or something, because I don't remember exactly.

Julie Cohn (00:08:23):

Who else was working on that problem? Who kind of, maybe competed or collaborated with you on trying to—?

Bernard Lesieutre (00:08:32):

Everybody was working on this problem. It was the problem. I mean, for 10 years, everybody was working on this. Big names on that. Thierry Van Cutsem from Lieges was a leader in that area. I mean, our group was working on it. That was Pete Sauer, my advisor, Pai. Pretty much everyone, I mean, everybody was working on this problem. But I think Thierry wrote a book. So, he's well known.

Julie Cohn (00:09:04):

Was there a moment when people said, okay, we've got this figured out?

Bernard Lesieutre (00:09:08):

A moment. I think figuring out that it was load-driven and we were just stressing the system too far, I think was figured out fairly quickly. What to do about it is another matter. And how it drifts into other things. So, we were looking at how it drifts. One of the things we're looking at is how it drifts into other types of instability that would start out this way. And then trigger dynamic instabilities and the like. So, it still goes on to this day. Studying this stuff. But I think we understand what's going on better.

Julie Cohn (00:09:46):

Do you want to jump in?

Daniel Molzahn (00:09:47):

Yeah, I have a couple of follow-up questions.

Daniel Molzahn (00:09:52):

You had mentioned there was a couple of voltage-collapse-related blackouts, or people attributed to voltage collapse and that kick started this area. But was there—other topics that people were working on or, so you said everyone was working on this—were they also working on other things or, this really sucked up all the oxygen in the room for a while?

Bernard Lesieutre (00:10:13):

It did suck up most of it. People were, of course, working on other things. There are people focused on controls and dynamic stability never went away. And people are trying to make machines more efficient and they're always trying to do that. And power electronics was more in its infancy in this area. It wasn't my primary area. But like I said, my first publication was in power electronics. They put my middle initial wrong in that publication. And it's caused no end of problems. So, I mean, there's other things, but this was the hottest topic in power systems. If you go back and look at the PES publications— Was it PES back then? Or was it still PAS? I don't remember. You're asking me things from like 40 years ago. But it was the hot topic. There's other things, I'm sure.

Daniel Molzahn (00:11:02):

So, it was, I mean, besides those blackouts, it really was driven by those blackouts. There wasn't—or potential blackouts there.

Bernard Lesieutre (00:11:10):

Yeah.

Daniel Molzahn (00:11:11):

Was that just because there wasn't—it was between—electricity markets were still far off in the future and we had kind of figured out other types of dynamics and so, this was the—?

Bernard Lesieutre (00:11:20):

Yeah. Well, I mean, there's real issues. People were worried about it. Because there's blackouts and people aren't quite sure if it's going to—their systems are next, right. So, they need to really understand it and model it.

Julie Cohn (00:11:33):

Were there non-academic engineers or scientists who also worked with you on these matters?

Bernard Lesieutre (00:11:41):

There were, I'm trying to remember who they were. At Illinois, we had a Power Affiliates program where we had industry people who were involved with the research, and they'd come down once or twice a year and have little mini-conferences about it. So, we certainly interacted with them. We had strong relations with other people, like General Electric, who did the PSSE, which is a common tool for simulating power grids. So, some of the work I've done over the years has ended up in their programs. Because they have to come up with models, load models, that work. And so, they were, we worked a lot with them back in those days. Let's see, Bill Price was a name working there. Juan Garcia.

Julie Cohn (00:12:35):

Was there were ideas going back and forth or was it a one way—in academic research labs, people were developing these ideas and then industry was kind of consuming the information? Or was there exchange back and forth?

Bernard Lesieutre (00:12:49):

No, no. It's exchange back and forth. Yeah. As it should be. So, we, and we still do that and work with people in the industry, find out what they're working on. Yeah, that's my favorite way of doing it.

Julie Cohn (00:13:04):

Is with industry collaboration.

Bernard Lesieutre (00:13:06):

Yep. I'm anxiously waiting on data from an industry member right now.

Julie Cohn (00:13:14):

That has to have been an ongoing issue for people doing academic research—was access to data to put into their models or test their models.

Bernard Lesieutre (00:13:24):

I think that's true. There's all kinds of issues with data. Some are obvious. People don't like to share data because they don't know what will happen to it. Or they feel very proprietary towards it. These days, data, people believe, could have national security issues. Or market data is concerned because it'll have financial issues or benefit some partners more than others. So, people are very concerned about how data will affect them. Back then it was a little bit less, especially with stuff with reliability. The NERC and related agencies used to collect more data that were made publicly available that they don't anymore.

Julie Cohn (00:14:15):

How is it actually transmitted? Like did you get a box full of discs that had data on them or—?

Bernard Lesieutre (00:14:22):

Right now, it depends on who you work with. So, right now I work with a group out in the West, Pacific Northwest, who are very, very careful about their data. They generally just like me to go there and get it. They will not submit it electronically, just won't. Now they're going to send me some discs and they're willing to do that. But I think they'd really prefer I actually just went there. So, people are very careful with the data. They don't transmit it electronically, this type of stuff.

Julie Cohn (00:14:52):

But in the 1980s—

Bernard Lesieutre (00:14:54):

In the 1980s, we didn't have as much data. Yeah. And that's absolutely true. We just didn't. Data was very scarce. I mean, I just think people didn't have the data. They don't monitor the system like they do now.

Julie Cohn (00:15:09):

Yeah.

Bernard Lesieutre (00:15:11):

Yeah.

Julie Cohn (00:15:15):

So, that was perhaps the most influential work you did. Was it the most challenging topic you took on

Bernard Lesieutre (00:15:22):

That aspect wasn't the most influential I did. That's where I got into this. So, I've done load modeling, you know, across my entire career for a long, long time. Yeah. I led a project—so there was a different phenomenon. So, that was the voltage collapse phenomenon. And then we sort of started to know what's going on. They had a different problem in the '90s where—and I was introduced as it happened in a number of places but introduced it by things they were seeing in Southern California, especially during the summer. And they would have small faults. There's little events that happen in the grid all the time. And then they have devices that protect that from spreading to other places. So, we have relays and things that'll just protect the grid, but they also want to bring the grid back up.

Bernard Lesieutre (00:16:15):

So, they would have faults that would normally occur that they're normally protected, but they would lead to surprising, unexpected results. And they would have the voltage—so a fault would happen in a location, and the voltage would drop, and the fault would be cleared, or it would do what it's supposed to do. But the voltage would stay low, and it would stay low for 30 seconds or 20 seconds or a minute. And that timescale doesn't sound that bad to somebody who's not a power engineer. But we talk on order of cycles, like one 60th of a second. So, 30 seconds is like infinity. It's loss of control of the system for infinity. So, they're very concerned about this phenomena because it's an absolute loss of control of the voltage in the system for what power engineers would consider a very long time.

Bernard Lesieutre (00:17:13):

I know it's just seconds. And that's, you know, to normal people, that doesn't sound like much, but we try to control the grid very precisely and very quickly. And so, they came up with a name for this phenomenon, this fault induced delayed voltage recovery. So, it's a very technical term that sounds like an engineer created it. And it is, and it's fault-induced. And the voltage did eventually come back up. There's a delayed voltage recovery. It actually went up too high. It would go above where the initial voltage was when it was done, typically. So, fault-induced, FIVR is the acronym. People use that acronym, FIVR. So, we're studying it. The hypothesis at the time that it had to do with air conditioners and air conditioners after fault would—would have motors in them, and these motors would just stall.

Bernard Lesieutre (00:18:10):

Or that was the hypothesis—that motors would just—air conditioning compressor, motors-driven compressors would just stall because of the—the physical characteristics of a compressor make it stall very easily in small air conditioners. They don't have a lot of inertia, and then they're pushing against something, and they just stall. And then the fault gets cleared, which means the electricity gets back on right away, or after a slight delay of a second or so. And then these stalled motors look like they're just shorts on the grid. Just short or a high impedance fault. And that's not good. It could be high current going through these things. So, I'm giving you the answer before we knew the answer. So, we saw this phenomenon. Now here's the answer, they look like shorts and then they have their own protection at the device level.

Bernard Lesieutre (00:19:03):

An air conditioner has its own thermal protection that after a while of being shorted, it will heat up and it has a thermal relay that would trip offline. And so, that caused the delayed voltage recovery because their own protection would not happen in synchronism. They would just happen when they happen. And then as these individual components would trip offline, the voltage would recover, but it then would exceed the voltage. Because these are all offline now. So, it's using less power than it was using before. So, it's not loaded and now the voltage is too high. And the real concern is at this point, because it takes a while for the system to recover to get back to the voltage again. It'll take a while before these things turn on and the system's just in a vulnerable state.

Bernard Lesieutre (00:19:57):

So, if anything else happened, the concern was then that could really make things a lot worse. So, I remember one year they saw this like four times in Southern California, and they were really curious about it. And the next summer they saw it 36 times and they were really, really worried about it. And then we started this project on load modeling. So, we went into the lab—there was labs at Southern—Southern Cal Edison had a lab working on this. There was a lab at Bonneville Power, and I used to go up to there and work with them doing testing of these air conditioner motors. And EPRI had a lab, I don't remember where it was, and they were doing this. So, we collected a lot of data on compressor motors. We'd go into the lab and actually fault them and see what happens.

Bernard Lesieutre (00:20:47):

And we just, it was, it was fun, right? You would go in and have these really fancy power supplies that you know, and we'd do different level faults and different levels of faults and study how these motors react. And yeah, sure enough they stall. And so, we created new models for this. And those models are used by industry today. They're in the PSS models; they're in Power World. They're part of the standard WECC composite load model. So, these models are used. And so, I contributed that

Julie Cohn (00:21:27):

Was the fix for systems to change something about how the power system operated or ask the air conditioner manufacturers to change something about how the air conditioner operated.

Bernard Lesieutre (00:21:38):

No, we went to the air conditioner manufacturers and they're all really nice and they're all, you know, they were happy to fix things as long as everyone had to do it. There had to be a rule because it was going to cost them money. And as long as it cost everyone money, then they're willing to fix it. So, nobody was against fixing it then, at that end. I think a lot of this problem has gone away on its own because of technology changes. Back when we were doing this, we were doing this in—when did we start doing this? Mid 2000's. Most of the compressor models, this is technical, were reciprocating compressor. So, they had pistons that were pushed by a motor. And it's a kind of a harsh technology for a load. Two things have happened since then.

Bernard Lesieutre (00:22:39):

Excuse me. Most of the compressor motors have changed to scroll compressors that have their own problems. They're different and not perfect. But they don't have the same type of mechanical load on the compressor, so it's not as harsh. So, that was one helpful thing, except, when there's a fault, a scroll compressor can get stuck in a mode where it turns backwards, which then is really bad too. It's not quite a fault, but it's something along those lines. It's operating very inefficiently, and it is harmful to the grid. If they were all scroll compressors all running backwards, we'd have a similar phenomenon probably. But they're not all that way. The biggest change that is probably going to fix this or is on the way of fixing this problem is power electronics. So, these motors, the scroll and reciprocating compressor motors in small devices are directly connected to grid power.

Bernard Lesieutre (00:23:43):

And so, the grid sees what's happening right away. There's no buffer. So, power electronics provide a buffer, and they help with ride-through over events like this. So, they're beneficial for this. So, I don't know how much we see this. I have been away from this for a while, so I don't know if people are still seeing these events or not. But we had to study them, and we still argue over these models. I belong to load modeling groups at WECC. They operate the grid in the west. And NERC, who has a load modeling working group that I belong to. And we, within the last year, we've been talking about these particular models.

Julie Cohn (00:24:28):

Do you have to tweak the models as the technology or modeling changes?

Bernard Lesieutre (00:24:33):

We should

Bernard Lesieutre (00:24:36):

We should. We have done that. So, we talked about redoing the scroll compressor, changing the models to represent those. And we did have some papers on it, but I don't think industry has adopted that yet. Studies have been done. Power electronics where everything is going is a little bit more generic, because what the grid sees is how the power electronics are controlled. So, what's on the other side matters a little bit less. It matters somewhat on the capacity of things, how the power, how much power be drawn, how much it's using. So, there's energy and power considerations, but it's a buffer. So, it doesn't actually see so much what's happening on the other side directly from the grid side. So, that, that is an enduring problem currently is how do we measure things that are connected through power electronics because it's mostly dominated by the controls on the power electronics.

Julie Cohn (00:25:33):

Why did those labs on the west coast have the equipment already waiting for you to come and do your various things?

Bernard Lesieutre (00:25:45):

So, those were both at utilities. And utilities are certainly interested in testing things on the grid scale. So, Southern Cal Edison had their lab facility. Bonneville Power has a utility. They have their own things. They have nice, nice facility up in Vancouver, Washington. So, they just test equipment all the time. But recently, we've been testing air conditioners, or heat pumps.

Julie Cohn (00:26:09):

So, they were already thinking about air conditioners in some capacity at that point.

Bernard Lesieutre (00:26:14):

I don't think they were thinking about that particular load at that point. But you know, they have the facilities to throw them in and do some— It's a little bit more complicated than that. So, they did have to update the facilities. Because you need a control temperature, you need a space—what do you call the spaces? A thermal space where you can control the temperature. Because when you're doing air conditioning, you need to actually heat up a space to put an air conditioner in and measure all that stuff. So, they did have to adapt their space. And I remember at Bonneville Power, they had this enormous thing where they'd topped a building, where they put a transmission line and big things like that. And there's a little thing in the corner where they built a room and made it thermally controlled and put the air conditioning in.

Julie Cohn (00:26:59):

That was the air conditioning room.

Bernard Lesieutre (00:27:00):

Yeah. Right.

Julie Cohn (00:27:03):

That's interesting. Did you want to—?

Daniel Molzahn (00:27:06):

Maybe—I had a quick follow up on that. Were there concerns about things besides air conditioners or everyone kind of zeroed in on air conditioners for this pretty—

Bernard Lesieutre (00:27:13):

No. No. So, there, there are other things. So, BPA Bonneville Power is very good about doing some load modeling tests. So, they were testing, and still do, test all kinds of loads just to see what they do to disturbances. And so, like I said, we're now testing heat pumps. They're redoing their labs, so they're shut down for about a year. But at that time, they were testing compact fluorescence lighting. Because lighting is a big load. So, if you go change the loading, then yeah. So, they're doing tests on that. Just anything. Computers—testing what computers do. Don't you want to do that some days? Put a fault on your computer?

Daniel Molzahn (00:27:53):

I'm trying to avoid that.

Bernard Lesieutre (00:27:54):

Yeah.

Daniel Molzahn (00:27:57):

For the faulted recovery stuff, was there, air conditioners were sort of immediately seen as like, that's the issue? Or—?

Bernard Lesieutre (00:28:06):

Pretty quickly? I wouldn't say immediately, but it was fairly quickly figured out that, you know, it's happening in the summer, that all these compressor loads—it just seemed like it was an air conditioning type problem.

Daniel Molzahn (00:28:18):

I see.

Julie Cohn (00:28:19):

And had the population increased in that area so that there was more air conditioning than had been connected?

Bernard Lesieutre (00:28:26):

Don't know. These are good questions. I don't know about that. That would be a concern of why you would want to react. These things happening. Those type of demographic changes.

Julie Cohn (00:28:38):

I mean, why the 1990s? Why would this show up in the 1990s?

Bernard Lesieutre (00:28:43):

Good question. Good question. Yeah.

Sairaj Dhople (00:28:46):

Julie, if I can interrupt

Bernard Lesieutre (00:28:49):

So, they did happen. There were instances that were known to have happened before then. I think TVA had an incident that probably predated that. So, yeah, I think there were some isolated incidents, but I guess it was more prevalent. It wasn't less, wasn't isolated things happening. They just started seeing it as a pattern.

Julie Cohn (00:29:12):

Sairaj?

Sairaj Dhople (00:29:14):

Bernie, I had a question. This is going to be a bit of a tangent. So, it doesn't strike me that you are someone who pays attention to things like Google Scholar, but your most cited paper is on averaging of DC-to-DC converters. We were just talking about impactful works. So, my question is, how did that come about and what impact did that have on your career?

Bernard Lesieutre (00:29:39):

That paper is cited a lot. So, how did it have an impact on my career? I'm not a power electronics person, so I don't know if I had much of an impact on my career personally. It came about, because we had a research group at the University of Illinois and one of my people I worked with, and actually lived with for a while, Dick Bass. His thesis was with Phil Krein. So, Dick was working on this stuff, and he was talking about this averaging. So, I said, "oh, I know about averaging." Because I knew of a type of averaging, but it was different than what they were doing. They were doing something called state space averaging that somebody came up with. It wasn't the rigorous, mathematical Russian averaging that I knew of that came out of the Russian mathematicians and engineers back in the day, probably going back to the '50s or '40s. And I don't remember how I came across this stuff. But there's a rigorous method for doing averaging. So, we sat down and started grunging through the equations, but with a perspective of applying this other technique. And, you know, took an afternoon's work and it was a very influential paper. It was. In power electronics, it gets cited a lot as an approach for studying power electronics using averaging.

Sairaj Dhople (00:31:03):

Somehow that didn't keep you on a track to pursue power electronics for your career. And there were other forces presumably that nudged you towards systems. Can you say a little bit more about that?

Bernard Lesieutre (00:31:20):

What was your question? So, why didn't I go into power electronics?

Sairaj Dhople (00:31:23):

Yes. Yes.

Bernard Lesieutre (00:31:27):

I have no particular reason. I was just pointed in one direction. Kept going that way.

Sairaj Dhople (00:31:33):

Alright, thanks.

Bernard Lesieutre (00:31:35):

From a load modeling perspective, though, it's been no end of headaches. Power electronics can be bad loads if they set out to be.

Julie Cohn (00:31:47):

What is a bad load?

Bernard Lesieutre (00:31:49):

So, at a fundamental level, we have voltage and current. So, we plug things in and current comes out of the socket and supplies the energy we need for whatever we're doing, for whatever work we're doing. So, a bad load would be something that an appliance maker sets out on purpose to make. Their perspective is different from my perspective. I'm from the utility grid perspective. They're from the end-use perspective and end-use perspective is that I want to do whatever work I'm going to do. If it's a dishwasher or a dryer or washing machine, I'm drawing electricity from the grid to do something. And I want to do that thing no matter what the grid does.

Bernard Lesieutre (00:32:37):

So, the grid might have a disturbance and the manufacturer, quite rightly so from their perspective, want to reject disturbances. They want to not have it impact the work they're doing. And for the examples I'm talking about, it's probably not critical if it did, but they still will design it so it will reject grid disturbances. If you're in a manufacturing plant in a factory, then it probably is important that you do this and it will—you don't want to stop an assembly line because of a little glitch on the grid. But, you know, for residential-type applications, who cares? But they'll still design these things to reject grid disturbances. And it's a totally fair perspective. So, where I'm going with this is when there's a voltage change, the grid would like it so the current would go down, so that it would be a friendly type of load.

Bernard Lesieutre (00:33:28):

So, if the voltage changes, you don't want the component to draw the same amount of power, because then that'll draw more current, which will make the voltage drop more. And you can get into a dangerous cycle that way. Usually it levels off, but it's got that tension to do that, or it's going to tend to do that if it draws the same amount of power. But when you're designing equipment that is going to do exactly the same amount of work, regardless of what the voltage does, it's drawing the same amount of power. It's being designed to be a constant power draw on the system, no matter what the system does. And that does initiate this feedback loop that's not favorable. It could potentially draw more current, drop the voltage, draw more current, drop the voltage. And so, it's an unfavorable load. And that's made easy by power electronics. Power electronics can do exactly that.

Julie Cohn (00:34:26):

And from the grid perspective, that's bad.

Bernard Lesieutre (00:34:28):

From the grid perspective, that's bad.

Julie Cohn (00:34:30):

From the power electronics and the—whatever device it's serving on the other side—it's good.

Bernard Lesieutre (00:34:35):

Yeah. And that's one reason why we test equipment still. So, when I mentioned the heat pumps earlier that we're testing, we tested a heat pump at Bonneville Power. I hope I'm not getting my, getting them in trouble. I don't think so. So, we're testing heat pumps and one we tested was a very friendly load. The voltage dropped, the current dropped, it was looking like or at least the current stayed the same. It didn't go up, you know, it was just a, what we'd consider a friendly load. We tested the next model up from the same manufacturer and it just looked like constant power. So, how do you know these things? So, you can reset this stuff. A lot of these are adjustable. You can set the settings when you install them and stuff, but nobody's going to, they're just going to take them out of the factory box and install them. So, yeah.

Julie Cohn (00:35:29):

Did you want to—

Daniel Molzahn (00:35:30):

I guess one question, maybe following up on the load modeling pieces. So, as part of these, you know, kind of larger groups that are deciding on the load models, how, how do you get consensus on what is the right model? I mean, are there kind of different researchers or different organizations that have competing ideas of what the model should be, and then you have to, you know, debate about how to best—how do you decide what goes into say, PSSE?

Bernard Lesieutre (00:35:56):

With difficulty. It really, it's an interesting process. So, I mean, academics can do anything and then publish a paper and we're happy. That's how we're judged, a lot of the times. It's just contributing to the literature. But on the industry side, there are people who make those decisions. So, the people that I work with closely in the west, the WECC, has a model validation subcommittee, now. Used to be a working group, and load modeling task force, which I'm now—I'm not sure if it still exists or is part of the subcommittee—but these people are working on this, reviewing models. So, people propose models and then people in these groups, and it's a large group, are studying them to see if they work, if they match the data. There's a big, a lot of work in validation, which, as the academics usually aren't involved with so much, because they don't have the data, and try to validate these models.

Bernard Lesieutre (00:37:02):

And then they vote. They vote on whether this will be part of a standard model, like the WECC composite load model. And the vendors have a seat at this table. They are at these meetings. They are part of these groups. So, the main vendors—Power World, PSSE, PSLF—these people are there at these meetings. And they implement these models, even if they're not approved of for testing purposes. We'll put them in their program so the industry people can test them out. So, even before they're accepted as, you know, full-fledged models by these groups, they exist in the software packages that the vendors produce. But yeah, it's very rigorous. It takes forever to get something through these committees. They're very, very careful.

Julie Cohn (00:37:54):

And is there a vetting phase even before that through the conferences and the publications? Or is that a separate trajectory?

Bernard Lesieutre (00:38:02):

No, well, it's potentially separate, but the industry goes to these conferences. So, like the load model we came up with, we presented at a PES meeting. There's a panel session on load modeling, and papers. So, it just could be something about our industry that it happens that way. But yeah, these things appear in the literature before then usually.

Julie Cohn (00:38:25):

So, there's a path from your lab or your computer where you're running a test, or whatever it is, through kind of a collegial review into this standard-setting process. But these are voluntary standards, I assume.

Bernard Lesieutre (00:38:46):

Oh, they are. These are not binding in any way.

Julie Cohn (00:38:49):

And so, they become standardized because that's what the product contains when somebody purchases the software.

Bernard Lesieutre (00:38:55):

Sure. And people don't have to use these models for load models and probably shouldn't for everything. You know, whatever type of study they have, they should use what is the best model they have.

Bernard Lesieutre (00:39:08):

So, there's no requirement. I'll back off on that. I'm not sure. There might be some studies that require you use particular models. But I don't know.

Julie Cohn (00:39:14):

How does a utility use the model?

Bernard Lesieutre (00:39:17):

So, they will—utilities make decisions over many timescales? So, they'll be doing planning studies out 10 years for a facility. Do I build a power plant? And they'll do a long-term study, which will be different than what these models are for. Then they'll have shorter-term studies, which are more seasonal. Like we have to plan for operating the grid six months from now. So, what will be online and what to expect the load be or what would be the worst case load we're going to worry about next summer or early fall if we're in the west. And so, we'll pose these in advance, because we're, you know, we'd be remiss not to. We're going to pose this in six months in advance and study the system. So, then we use these as simulation models to simulate the system under a bunch of scenarios of things going wrong. What if we lose the Pacific DC Intertie, or we learn lose Palo Verde or some type of large generator station. They'll run these simulations, they run thousands and thousands of simulations, see what happens. And that will inform them on how much power that can go from Pacific Northwest to California or, these days, vice versa. So, they make all kinds of decisions based on this, and they use these simulation models to do exactly that.

Julie Cohn (00:40:42):

So, the customers are not strictly utilities per se, but they might be system operators. They might be transmission line planners, generating planners, generation investors.

Bernard Lesieutre (00:40:56):

Could be. Certainly, the grid operators do this. These types of studies. So, Cal ISO is doing these all the time. All the rest are.

Julie Cohn (00:41:12):

I'm very curious about your work at the intersection of engineering and public policy. I wonder if you'd be willing to talk about that a little bit.

Bernard Lesieutre (00:41:21):

Public policy. So, currently I'm engaged with load modeling groups in the west and with NERC. And so, they are on the edges public policy. And we're just trying to find the best models for people to use to make decisions for the grid. I had one instance where I was involved at the federal level hat's kind of interesting. I think, so anyway. After the 2003 blackout, which took out the Northeast, Congress passed the Energy Policy Act of 2005. And in that Act, they—I'm trying to think of the right word. They gave authority to FERC for reliability of the bulk power system. I don't know if "gave" is the right word. They imposed upon FERC, the responsibility of reliability of the bulk power system. And so, Congress passed this law.

Bernard Lesieutre (00:42:32):

It says something to that effect, that FERC is responsible for the reliability of bulk power system. But nobody had a definition of what bulk power system is. So, first thing FERC was faced with is determining what they were responsible for. That you're responsible now for the bulk power system. Well, what is the bulk power system? There used to be, prior to that, a rule of thumb that said anything operating over 100,000 volts is part of the bulk power system. Below that is, you know, sub-transmission and distribution. So, 69 kilovolts is a common one, but it would've been considered sub-transmission. And then there's things at like 33, which is getting closer to distribution; 24 and 12, you know, it's more distribution. And so, there was a sort of—this rule of thumb, but nobody likes regulation. So, industry started pushing back on this right away.

Bernard Lesieutre (00:43:30):

Because there is no definition. And so, this rule of thumb with 100,000 are arguing, well, no, it really should be 230. So, then that would remove all the 135 KV lines or 165 KV lines, and remove them from

FERC jurisdiction, because nobody likes regulation. They don't want—I mean, they're not bad people. They want the grid to be running; they want it to be reliable. But people push back on these things. So, we got engaged with FERC to help them with this decision. So, we came up, and Chris DeMarco, did you talk to Chris about this?

Daniel Molzahn (00:44:09):

A little bit.

New Speaker (00:44:10):

Okay. So, you know all about this already.

Julie Cohn (00:44:12):

He didn't really discuss this in any detail.

Bernard Lesieutre (00:44:16):

Okay. So, that was a fun project. So, we came up with a method for ranking, based on models and fancy math, of ranking the importance of facilities in the power grid. So, literally doing that, ranking this is the most important facility. This is the next one. Down to ones that were the least important. And the view from our perspective was to identify the least important. And they would not be under the jurisdiction of the Federal Energy Regulatory Commission. And things like distribution networks would come out as at zero. They just would be unimportant, and the math would come out that way as well. And then there's this whole array where there's things dropping off really quickly. And so, there's a thresholding thing. You'd say, well, you get thresholded here. And that would be stuff that's outside the jurisdiction of the Federal Energy Commission.

Bernard Lesieutre (00:45:11):

It's down at a level that they needn't be concerned. But of course, when you make a ranking system like that, that's not what people are looking at. They're looking at the one, two, the top 10 that are on the list. And so, that was vetted before we even published anything. Before we put it before FERC, you know, FERC was talking with engineers at many utilities and the like. So, we went to them with this list on the East, and they thought it was a very good list. They looked at the top 20 and said, yes, those are some of the most important facilities in the Eastern Interconnect. And so, it seemed to be fairly successful. So, we, Chris and I and a student Dan Schwarting, went to FERC, made a presentation to

FERC, one of those things where there's a panel of people up there and there's people watching you, behind you, where they're asking all kinds of questions—that was quite an experience.

Bernard Lesieutre (00:46:08):

And we presented it, and then we wrote a final report. Then they had a period of questioning where they gathered feedback from utilities. It's just a standard procedure. So, people wrote all kinds of things and then they asked us to review it. They never published our reports because they kind of figured out, and we were a little bit slow on this—like I said, we're focused on the low end of this list, trying to figure out what's the distribution level, not the high end—but the idea of identifying the most important facilities and telling people how to do that was sort of deemed probably not such a great idea. So, they didn't publish our results. But they did hire us for two more projects to help identify the most important facilities in the grid.

Bernard Lesieutre (00:47:02):

So, they liked the work, but they didn't want it to be so public. Chris and I once, after that, went to one of our meetings, we saw a report was stamped, you know, confidential. They had classified it, which is funny because none of our—at the time, University of Wisconsin couldn't do classified research. And we had already published this anyway, so—.

Julie Cohn (00:47:22):

That's interesting.

Bernard Lesieutre (00:47:27):

But that impacted public policy. They didn't adopt it for their rule for determining this particular question for those reasons, I think. I believe those are the reasons. Nobody told me. But it did have an impact. And in the end, they just went back to the rule of thumb of 100,000 kilowatts. Maybe we scared off the people who were against it by our fancy math. I don't know.

Julie Cohn (00:47:54):

But did you say that FERC initially came to you and asked you to do this work? Or were you one of many groups that was providing input on what this, how this should be done?

Bernard Lesieutre (00:48:04):

My understanding was, before they were working with some other group and were not satisfied with the results, the results weren't vetting with the people they were talking to. And we went to FERC to give a presentation on something entirely different, using a similar method. And I don't even remember what it was for, but it was using a similar method and somebody very insightful thought this could be adapted to what their problem was. And then they invited us to talk about it and look at it. And yeah, that's how it happened. We actually gave a talk on something else, but it was using similar tools we used in the end for that. And they thought it might apply that that was a very. It's very quick to pick up on that actually. Yeah.

Julie Cohn (00:48:50):

And that's an example of a very overt and directed public policy initiative. Like: how are we going to define the thing we regulate?

Bernard Lesieutre (00:49:00):

Yeah. Yeah.

Julie Cohn (00:49:01):

So, it sounds like there were a lot of stakeholders involved in looking at it.

Bernard Lesieutre (00:49:06):

There a lot of interested parties.

Julie Cohn (00:49:08):

Yeah.

Daniel Molzahn (00:49:10):

Can you say more about the notice and comment process? Like were there any industry comments that came back that were interesting or relevant? I mean, people understood it or it was—?

Bernard Lesieutre (00:49:19):

They had lots and lots of comments. But they weren't technical, so they didn't burden us—Chris and I weren't burdened with those. They did send us some of the technical responses and there were two that were actually their most interesting. One was actually thoughtful. Somebody had actually gone through our report, actually understood it. Actually, had some fair questions and comments about it. And we were very good about answering those questions in our final report. I don't know if that person ever saw our final report because it never got published. So, I don't know if the people who submitted that ever got the answers to their questions or not. Then there was one that was somebody who just didn't get it, and I think purposely so, was just saying this wasn't correct. But they didn't—I want to say they didn't understand it, but I think they were trying to, they were hired to not understand it. Personal opinion.

Julie Cohn (00:50:22):

How closely did the final rule of thumb overlap with what would have resulted had they used your method?

Bernard Lesieutre (00:50:30):

That's a good question. I don't remember. I'm going to guess; we did study this. It's in our reports. So, we definitely, our stuff definitely, in different parts of the country, would've been below that. So, like there's parts of northern Wisconsin where I think the main—correct me if I'm wrong, Dan—but they're doing a lot of stuff at 69 kilovolts.

Daniel Molzahn (00:50:58):

Yeah.

Bernard Lesieutre (00:50:58):

There's parts of, maybe more rural parts, of the country that will use lower voltages, lower than a hundred kilovolts. And we found those. And I personally think it makes sense that those should be included in the bulk power system. They're probably not at this point, I don't know.

Julie Cohn (00:51:14):

Yeah.

Bernard Lesieutre (00:51:16):

So, I think we would've erred to the side—The rule of thumb might be missing some things that we caught. I will stick up for ourselves. I think the ones that we would've said would've been part of their jurisdiction really should be.

Julie Cohn (00:51:30):

At the beginning, you mentioned that load modeling was perhaps one of the more dominant themes of your work, but not what you consider the most fun. Would you like to talk for a minute about what you do consider the most fun parts of your work?

Bernard Lesieutre (00:51:46):

We write these theoretical papers every now and then. So, we wrote one on—what I have to do, I remember what year it was, now what was the title? "Convexity of Power Flow Equations." Because, and it's a mathematical concept that is very convenient and people were wanting things to be convex, but they're not. And back then we didn't actually know if the models we were using were convex in the way that we were using them. And it made an impact on markets—electricity markets. And in the particular application we applied our results to in that paper had to do with financial transmission right markets. Because there was a fundamental paper that was published and adopted by usage for the operation of financial transmission markets that said they were revenue adequate.

Bernard Lesieutre (00:52:45):

That means the way the FTRs, financial transmission rights, work is that when there's congestion in the system, money is collected and it goes, is dispersed to people who have these financial transmission rights. So, people have rights on transmission lines related to congestion and—oh, this is getting, it'd be very hard to explain it all in one go. But they have rights to it. So, they collect money when there's congestion, but that money comes from somewhere. So, somebody has to collect the money. And the way the system operates on the financial transmission rights was designed so that they were guaranteed to be revenue adequate, that they collected enough money to pay their obligations. So, that was the thing. But the premise was that systems are convex. But they're not, or they didn't know if they were in the space, you know, projecting onto the space we were talking about, which was an active power space. Was that? Well, whatever space—this is years ago, 20 years ago. But they're not. We wrote a paper that showed that they weren't, and it didn't change anything. They still operate to this day; they still operate financial transmission rights exactly the same way. But they aren't revenue adequate. They just aren't. They never were, they have never been revenue adequate.

Daniel Molzahn (00:54:13):

Do you know how much of that is—I don't know—?

Bernard Lesieutre (00:54:16):

Billions of dollars.

Daniel Molzahn (00:54:18):

But how much of it is due to non-convexities and how much of it is due to not having the same model?

Bernard Lesieutre (00:54:22):

So, there's a number of aspects going on. So, the model that they used to allocate the financial transmission rights is probably almost never the conditions in which systems operating where congestion occurs. I don't know. Because to even apply that question, you have to have the same model in the same conditions. And so, there's no way to know.

Daniel Molzahn (00:54:52):

It's an unfair question on my part. I don't know.

Bernard Lesieutre (00:54:53):

No, it's a fair question. So, I don't know if the non-convexity is an issue or not. It doesn't help. But it's worse that we're making decisions on the wrong models and we know we are. And it is—the financial transmission rights—the mismatch is huge. So, it really is—I haven't looked in a number of years, but it was hundreds of millions of dollars per year it was off. So, they're not revenue adequate, but they operate these things anyway. Because they have to. They have to do something.

Julie Cohn (00:55:30):

How did this question become something that you felt compelled to think about and address?

Bernard Lesieutre (00:55:37):

Oh, I don't know. It's the thing that people talk about over coffee at conferences, right? Well, is the system convex? Is it not? It's a very mathy question. I like those, but they're not, you know, they don't have a lot of impact, I guess.

Bernard Lesieutre (00:55:52):

Like, except for the dozen people who read those papers. You've read those papers.

Daniel Molzahn (00:55:56):

I read those papers.

Bernard Lesieutre (00:55:58):

Sairaj might have read this paper. Maybe not. Those are the fun ones. I like those. There's probably more like that too. We have papers on calculating and bounding the number solutions to the power flow equations. Totally, no real impact there, but it's a lot of fun. And I think those are good ones and Dan likes those too. I can see Dan laughing. I know Sairaj likes that stuff too, but it's not having an impact on the industry at all.

Julie Cohn (00:56:30):

Well, but does the process of working through those questions ever feed back into the way in which you address a real-world problem that somebody's asking you to solve?

Bernard Lesieutre (00:56:38):

Potentially the way we think about it does. No, the way we approach problems like that do. So, yeah, the type of tools we'll throw at things will be informed by looking at these unusual things. And that's certainly an argument we always point out. So, thank you for bringing that up. You know, when we do these strange things, they actually do have value and there is a lot of value to that stuff.

Daniel Molzahn (00:57:02):

And maybe one quick follow up on that, because you had mentioned earlier about operating on the wrong side. The PV curve, right? So, that would be an example presumably where these multiple solutions matter.

Bernard Lesieutre (00:57:13):

Yeah. Yeah.

Daniel Molzahn (00:57:14):

Is that—so, and, and I meant to follow up on this before. So, you said there was evidence of that happening sometimes? What was that evidence or what—?

Bernard Lesieutre (00:57:23):

People showed the—what was it? At some point the power is going down and the voltage is going down. So, it was going the wrong way.

Daniel Molzahn (00:57:35):

I see. So, it was the sensitivities?

Bernard Lesieutre (00:57:36):

Yeah, it was data over—whatever range they were looking at—and was doing stuff like that.

Daniel Molzahn (00:57:43):

And measured from an actual system?

Bernard Lesieutre (00:57:44):

Yeah. Measured from an actual system. But I don't know that that's been published. That was presented at a forum somewhere. But it's probably published somewhere. Then there was the cases with the power flow solutions that aren't desired. One where you have the loop flows, like the Lake Erie flow, where you had power flowing in a loop around Lake Erie. That certainly is published. And that's just not the way you want to operate the grid. It's totally inefficient, you know. It's lossy to just have power flowing around the lake, not doing anything, just flowing around the lake.

Julie Cohn (00:58:24):

When, when did that—?

Bernard Lesieutre (00:58:26):

Oh, that one goes back to the '70s, I think.

Julie Cohn (00:58:29):

Has it been addressed?

Bernard Lesieutre (00:58:32):

It's such an unusual problem that it's not something that people worry about. They just bring it up when they want to bring up interesting phenomena.

Julie Cohn (00:58:39):

And is that because of the physical layout of the grid connections at that location.

Bernard Lesieutre (00:58:45):

Yeah.

Julie Cohn (00:58:45):

The particular size of the lake and where the land is versus—

Bernard Lesieutre (00:58:51):

Yeah. It probably does have to do with the demographics around the lake. Because it's pretty built up on the Canadian side. So, there is transmission there, and certainly on the American side. And other locations where you have lakes, that probably isn't happening as much. But I don't know.

Julie Cohn (00:59:08):

Another question about your mathy interests is when you have published these papers for the dozen enthusiastic readers, are any of them outside this field? And taking your ideas back to the centers of mathy work?

Bernard Lesieutre (00:59:26):

We had one that happened like that. So, this is back when I was at MIT, we introduced something called the "influence model." And it was a couple of Markov chains. So, we had nodes where the Markov chains would influence each other between nodes. And we were studying cascading outages and power systems in a very abstract way by using this. And so, it was fun math. It's a little bit off from the power system in detail, but it would capture ideas of cascading outages. It has been used extensively, but not in power systems, been used in computer science. If you Google "influence model," it's too generic of a term, you'll find lots of stuff. People call a lot of things "influence model." But if you find our influence model, you'll see it used in computer science much more than what we've used it for. So, it took off for a while in computer science.

Julie Cohn (01:00:32):

One of the things we've been curious about—,

Bernard Lesieutre (01:00:34):

We didn't tell them. It turned out one of our students had a graduate student roommate who's in computer science, and they thought this was fabulous and they took off with it.

Julie Cohn (01:00:45):

Interesting. One of the questions we've had on and off throughout this project is, observing some parallel advances in power systems control and operations and optimization, and some developments in computer hardware and software. And we've been asking, to what extent does one influence the other or create opportunities for the other? And has there been flow back from the power systems side to hardware and software development on the computing side?

Bernard Lesieutre (01:01:19):

So, I'm going to show my age.

Bernard Lesieutre (01:01:22):

But when I was an undergraduate, I was the first class not to use computer cards. So, yes, there's back and forth. This is very historic. So, things like sparsity techniques were developed for studying power systems. So, those techniques that are fundamental to what we do now in all kinds of computing were developed by people who were studying power systems. So, that's a really big one that's went back the other way. Computing is one of the biggest things that's changed over my career. Because we used to do a lot of reduced order modeling. I'm not answering your question directly. I used to be involved with reduced order modeling. Because our simulations used to take days. We'd run a simulation, we would take days, we'd leave the computer running for days. And then I remember sometime, probably in the '90s, late '90s, maybe 2000, where we were writing proposals and we, we stopped and somebody pointed out, you know, this is something computers are just going to fix.

Bernard Lesieutre (01:02:28):

They're just going to be so fast. We don't even need to worry about this problem five years from now. So, we took it out of our proposal. It's just not a fundamental thing that was limiting anymore. So, computers have influenced what we do or what we think is going to be the problems, because just how powerful they've become. And we should be thinking that way now with integrating AI with the type of things we're going to be proposing. I don't know how. Maybe somebody younger—looking around the room—will figure out how to do that. But yeah, the capability of computers really influences the things we do, and we should be thinking about that. But real-world problems always influence how computers are used and algorithms that people develop are always influenced by our type of problems. We like working with the computer science folks here and they like working with us because there's real problems that they find challenging.

Julie Cohn (01:03:26):

Sairaj, I know you were planning to jump in if you had a question, but I thought I'd double check.

Sairaj Dhople (01:03:31):

Yeah, I just wanted to maybe pick up on what you just said, Bernie. If you had to forecast deep into the future, do you feel like there are problems that the community is working on right now, which are going to be non-problems in the future?

Bernard Lesieutre (01:03:48):

Well, I'm an egotistical engineer. We're going to solve all the problems. So, the ones we're working on now won't be problems in the future because we'll solve it. I really do believe we will solve the problems. I mean, in the long term, we do have to worry about where our energy's going to come from, but that's not a new problem. So, I think renewable energy is something that will have to stick around.

Sairaj Dhople (01:04:21):

Okay. I knew that that was an unfair question, because it requires you to, to forecast into the future. Let me, let me ask you a—

Bernard Lesieutre (01:04:28):

People ask when I give presentations, "Where do you think we'll be 50 years from now?" And that's a fair question. So, even in terms of the structure of the grid, will we have little cold fusion reactors in every device, and we won't even have a power grid anymore because we won't need it? Or will fusion come around at a central station level and then we'll again, return to large central station facilities and we will require a very robust transmission grid? Or not? Will we have central stations or not 50 years from now, I think, is unknown, that we don't know. And it will be totally dependent on what technologies we develop in the next 20 years or so, although we've been working on fusion for much longer than that. But they always seem so close, and they seem close now.

Daniel Molzahn (01:05:17):

Particularly this article in IEEE Spectrum, I read recently, about the experiments going on downstairs.

Bernard Lesieutre (01:05:23):

Oh, yes. The accelerator.

Daniel Molzahn (01:05:26):

Are those folks that you've worked with at all during your time here on the—?

Bernard Lesieutre (01:05:30):

I haven't. Certainly, know them and Dave Anderson was a big name, so we'd always show off their facility and they always love showing off their facility. You should go downstairs if you haven't seen this facility yet. You've seen it, haven't you?

Daniel Molzahn (01:05:43):

It's very cool.

Bernard Lesieutre (01:05:43):

It's a really, really cool facility. So, before you go, check that out. They always seem close and they're always making breakthroughs, so we'll see. But it really would have an impact, or of course maybe they could miniaturize it, and we can all have fusion reactors operating our phones, if we even have phones, it'll probably be something totally different. I remember being at a presentation by Donald Knuth, at MIT, this guy developed tech. And he was in computer science. Really famous, and they asked him this question, "where will we—what would be the great thing that will happen in 50 years, or something?" He said, "telepathy." Okay. Well, not sure that would be a good idea, but that was his response. I don't know.

Julie Cohn (01:06:28):

50 years might have been something about telephony, but I—

Bernard Lesieutre (01:06:31):

Yeah, right. Exactly.

Julie Cohn (01:06:33):

Go ahead, Sairaj.

Sairaj Dhople (01:06:34):

Yeah, I'm going to then, instead of going into the future, take you a little bit back into the past. Can you say a little bit about the time you spent at Illinois? You got all your three degrees there, you were there in the early '90s surrounded by giants like Pai, Sauer, and I think maybe even Ian Hiskens. What was the atmosphere there? Like, did you realize that you were in the, you know, basically the center of power systems research at the time?

Bernard Lesieutre (01:07:01):

Says an Illinois grad? He's a bit biased.

Sairaj Dhople (01:07:04):

Not a biased comment at all. Yes.

Bernard Lesieutre (01:07:08):

No, it's, didn't have any sense. We were just having fun. Okay. That's too short of an answer. I see. We really, we did really, we had a great group there. We all got along, all the students and faculty. We had weekly seminars like we do here, except we got credit for it at Illinois. You don't get credit for it here. I mean, like one credit this semester. We got academic credit. And we had weekly seminars and those were entertaining. Ian Haskins wasn't there at that time, but Marija Ilic was, so it was—you know—Marija, and Pai, and Sauer, and Phil Krein was new. So, yeah, that was a very, very strong group. It's different than now. So, power systems groups are really big now. Back then it was sort of the lean years, it was really small, so there weren't many universities that had power programs like we do now. I don't know. It was great when we were having fun working on stuff.

Sairaj Dhople (01:08:20):

And then was there a specific incident or a course or something to that effect that drove you into choosing the power area as—?

Bernard Lesieutre (01:08:32):

Electrodynamics. Yeah, motors. Motors are the coolest thing ever. That got me into this. And I remember after taking that course, going up to Professor Sauer's office and saying, "can I do anything in this?" And he said, "yeah, of course you can." He was most supportive guy ever.

Sairaj Dhople (01:08:54):

Right. Thanks for sharing that, Bernie.

Bernard Lesieutre (01:08:56):

Yeah.

Julie Cohn (01:08:58):

Did any of you who are joining us have a question you'd like to ask?

Aditya Rangarajan (01:09:04):

I have one. Earlier we were talking about supporting voltage recovery. Was there something particular to the compressor motors that caused this? Because I, assume there are a lot of other kinds of motor loads in the network.

Bernard Lesieutre (01:09:18):

There's really interesting things about compressors. So, they compress. So, initially when you turn one on, it has very light load because there isn't any back pressure yet. You haven't compressed it yet. And manufacturers optimize things to be very efficient and very cost-efficient at that. So, you have this goal of compressing to a certain level, and compressors have a little inertia, not a lot, but they have some. So, they would actually design it that, when it's reached its compression stage, it would rely on the inertia of carrying it through its cycle, so that if it stopped, it would not be able to restart until the compression released. By design. By design, you need less mass to do that. Lower inertia. You can get by with a smaller motor for that same compression. So, that in steady state, in a cycle where it's pushing a piston coming back, it would rely on the inertia of the motor to carry it through that cycle.

Bernard Lesieutre (01:10:28):

And I learned that, and I thought that was wild. It's really wild. You do it, but you save money, and it would still operate, but then when it does stop, it can't restart until the pressure equalizes. So, that was an interesting thing. Is that part of your question? It's an interesting thing about the compressor motors that way. Scroll compressors work differently. They have a spinning thing that's off axis and so, it'll spin and then it will compress air around this little spinning thing and push it out the other end. Its problem is, when it stops, the back pressure can have it actually start turning in the other direction, and then it doesn't recover when it starts turning back on. It actually just operate backwards, trying to compress in the opposite direction unsuccessfully. Those are the two main technologies. Most everything is scroll, everything new now, are mostly scroll compressors, everything. There's probably plenty of stuff still out there that's old and has reciprocating. More detail than you asked for. See, that's what you get when you've been around, you learn so much about these interesting things.

Julie Cohn (01:11:45):

Yeah. looking ahead and we've, you've already alluded to some of these things or discussed some of these things, but as the non-engineer looking across a future grid, it looks like more and more things will not be motors that connect to the grid. They will be power electronic devices.

Bernard Lesieutre (01:12:06):

Right. They'll look like power electronic devices. There'll still be motors, but they just won't see them from the grid.

Julie Cohn (01:12:12):

Right. The grid will not see the motors. Will that fundamentally change the way in which load flow modeling should be done?

Bernard Lesieutre (01:12:22):

It'll change how some studies should be done. A typical load flow won't. But I don't think you meant it generic like that. The load flow won't because we're predicting conditions out a day or a month or a season, and we just want to know what the load is and whether we have enough generation and the transmission line can carry it. But for the dynamic studies that I was talking about, where we try to study the reliability of the grid, it will change those. And already is changing those studies. We have power electronic models in our models and they're just going to increase. Typically, they're being treated as constant power. But we discuss, I mean, the current thing we're working on, our data center models and working on how those should look. Electrolyzer facility models is another one the group is looking at.

Julie Cohn (01:13:15):

Could you hope to change how you abstract what they're doing to the grid into a mathematical model, or just think about, there are more of them, and we have different ways of controlling them.

Bernard Lesieutre (01:13:29):

So, it's where the controls come in. So, the backend devices do matter because they're controlled in different ways. And to what extent those controls are seen by the grid is what is going to ultimately show up in the models. The issue is that vendors don't like to share what their controls are. There was a FERC order a couple years ago saying that people have to provide enough information for grid operators to make their decisions. And directed NERC to create some rules to that effect. I haven't followed up on that to see where that is, but in the end, they are, NER is being supported by FERC to impose any rules they need to, to make the grid reliable. So, they're being empowered to do it.

Julie Cohn (01:14:18):

You'll be in front of the FERC panel once again.

Bernard Lesieutre (01:14:20):

Yeah. Maybe.

Julie Cohn (01:14:23):

Yeah. Are there any topics you were hoping to talk about that we haven't covered yet today?

Bernard Lesieutre (01:14:34):

No. I didn't know what to expect. You never asked me, "did I meet Edison?" You know, did I meet anyone who has met Edison? I think I have, but yeah, those type of questions.

Daniel Molzahn (01:14:47):

Who did you meet that you think you met Edison?

Bernard Lesieutre (01:14:51):

So, I was trying to think of the oldest engineers I've met. Charlie Concordia in our area. But I met Frank Rientjes once and somebody told me he had met Edison. I don't know if that's true or not.

Julie Cohn (01:15:03):

What was the context in which you met Charles Concordia?

Bernard Lesieutre (01:15:06):

Oh, just at a conference. He used to go to these conferences in the '90s and just introduced myself. I didn't have any meaningful conversation with just, "hi, I'm Bernie. How are you?" Yeah, I didn't work with them at all.

Julie Cohn (01:15:23):

Sairaj has a question that we often invoke to close out the interview.

Sairaj Dhople (01:15:31):

Bernie, any words of advice or wisdom that you would offer to a future generation of power engineers that's surely listening to this interview?

Bernard Lesieutre (01:15:41):

Advice? The usual thing is, just be good engineers, be good people, honest. Keep your integrity, you know, focus on the technical decisions you need to make to keep the grid operating. That's my advice. What else?

Bernard Lesieutre (01:16:09):

I mean, my concerns with engineers is, you get faced with all kinds of pressures outside of engineering, but, you know, just stick with your engineering results. Stand up for them. It's also good advice. Now that I mention it, that you mention it, is we are better if we are in tune with other people's perspectives. So, understanding the financial aspect of things is important. Understanding the regulatory aspect for things is important. So, here at the University of Wisconsin we have something called the Energy Policy—. What is it called? EAP, Energy Analysis and Policy Program. Where it's energy analysis and policy and people from across the university; graduate students, limited to graduate students, who study these aspects. And so, some of the engineers that have gone through that have become really better engineers and people who work in a regulatory environment by understanding these other analysis analyses and other perspectives.

Bernard Lesieutre (01:17:23):

We have a graduate who works at FERC who tells me early on what she did there was just translate between lawyers and, and regulatory people and engineers because she could speak all their languages. So, I think those type of tools are really important for us as well. Because we're not going to be very useful if we can't talk to other people. So, when you do talk to them, stick up for your engineering results. Don't let them tell you they're not important, but being able to tell them that in a language that they understand, is probably a very useful thing.

Julie Cohn (01:17:56):

That's great. Thank you so much. We really appreciate your time. Perspectives. Your memories. Really appreciate it.

Bernard Lesieutre (01:18:04):

You're welcome. Thank you for the opportunity.

[End of interview]