Algorithms & Power Systems Architecture:

Using Historical Analysis to Envision a Sustainable Future

Oral History Project

Interviewee: James Kirtley

Interview Date: July 18, 2023

Place: Hyatt Regency Hotel, Orlando, Florida

Interviewer(s): Julie Cohn, Sairaj Dhople, Daniel Molzahn, and Brian Johnson.

Keywords: James Kirtley, Massachusetts Institute of Technology (MIT), 1965 Northeast Blackout, Herb Woodson, Jim Melcher, electromechanics, turbine generators, nuclear power, Electric Power Research Institute (EPRI), General Electric (GE), system models, Mitchell Unit Two, Fred Schweppe, load control, demand-side management, frequency adaptive power energy regulator (FAPER), microgrid, superconductors, Lincoln Labs, state estimation, radar control, IEEE Transactions on Energy Conversion, Office of Naval Research.

***Abstract*:**

MIT Professor James Kirtley discusses his academic and professional history in this interview. He explains his early educational focus on electricity, his work at Raytheon with microwave tubes, and the events of the 1965 Northeast Blackout that piqued his interest in power systems. He notes influential professors at MIT, including Herb Woodson and Jim Melcher, steered him toward turbine generators and nuclear power for his Ph.D. research. He describes working in industry prior to taking a position on the faculty at

MIT. His work involved building scale models of generators and later power systems, to verify computer simulation routines. He discusses modeling transients and subtransients on these machines. He later describes transmission simulator systems built in his MIT lab. These were used to simulate causing loads to respond to the needs of power systems – this would allow the use of load to support frequency regulation. Dr. Kirtley concurs that Fred Schweppe's work in this area laid the groundwork for today's demand-side management initiatives. He mentions several influential power systems experts in the lab, especially describing the role of Fred Schweppe as both visionary and leader. Kirtley discusses work on turbine generators, in particular efforts to air cool large machines. He describes collaboration with different industry groups, corporations, and government agencies, both in the United States and elsewhere. He talks about applying work on turbine generators to applications in the military and in aviation. Dr. Kirtley discusses his eight years as editor-in-chief of the IEEE Transactions on Energy Conversions. His reflects on changes in IEEE's approach to publications, in the past papers might include comment and an author's response, allowing for written discussion of technical topics. He discusses briefly the future of the grid, with large additions of renewables, and the likely need for rotating turbines, perhaps nuclear, to provide stability. He closes by encouraging today's graduate students to have broad interests and hands-on experience with electric machinery.

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

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

Julie Cohn (00:00:21):

This is Julie Cohn. I'm conducting an interview with James Kirtley on July 18th, 2023, at the Hyatt Regency Hotel in Orlando, Florida. And here today are Sairaj Dhople and Daniel Molzahn to assist with the interview, as well as Sutanwi Chatterjee, Rachel Harris, Mahbubul Bhuiyan. And Brian—

Brian Johnson:

Brian Johnson

Julie Cohn:

Johnson, all of whom may ask questions during the interview. During today's interview, we are especially interested in your work on power systems-related topics and your collaboration with colleagues at MIT. We'll begin with some introductory questions and general background information from you. And we'd like to ask if you would be so kind, if you could describe your educational background and your professional positions in the field of electrical engineering.

James Kirtley (00:01:32):

Sure.

(00:01:36):

Well, I—how far do I go back? <laugh>

Julie Cohn (00:01:38):

As far as you—well, we're very interested in your earliest engagement with electrification and power systems.

James Kirtley (00:01:47):

I went to public schools in Palo Alto, California and Ridgefield, Connecticut. And in high school I was a radio amateur, so I already had a bent toward electrical things—things electrical—when I went off to college at MIT. My undergraduate education at MIT was not particularly distinguished, although I did tend to like the physical activities—laboratory stuff—more than theoretical work as an undergraduate. And one of the things that I think did get me interested in this was the Great Blackout of 1965. I was a co-op student at MIT. In fact, I was working for Raytheon doing work with microwave tubes, used for radar jamming and military applications. Anyway, I was driving home; driving right past the radio station on Soldiers Field Road and listening to that radio station when it went off—the air just went silent.

(00:03:11): And I noticed it was a dark and cold night. So, I followed Soldier's Field Road and went underneath the Boston University Bridge, and there was MIT all lit up. I thought, well, probably not a blackout. Well, it was a blackout and MIT had managed to survive. It had a little power plant of its own. And well—that was while I was still an undergraduate, and then I started graduate school and didn't really have a serious focus. But when I passed the oral qualifier—which was one of the steps in getting a PhD—I walked into to Herb Woodson's office. Herb was a professor at MIT at the time, and he was the guy that was in charge of the undergraduate course that I had done best in.

Sairaj Dhople:

Which was?

James Kirtley (00:04:27):

"Electromechanics." It was taught out of the textbook that Herb and Jim Melcher had written, *Electromechanical Dynamics*.

(00:04:37): And I thought that Herb would be a guy that I could work with for a PhD. I walked in; I said, "I'm looking for a PhD thesis." And at the time Herb had just finished working on a project that hadn't worked out, on Magneto hydrodynamic generation. And I had—I thought that might be an interesting topic to work on, because it was closely related to the stuff they were doing in that course. Effectively you fire a rocket engine through a magnetic field, and through J xB, you get or V x B, you get electric fields and take energy off. Didn't work out very well because air is a pretty good conductor when it's at rocket engine temperatures, but it cools off very quickly. And so, most of the energy in the rocket engine stream is wasted. Anyway, that project was not really available, but Herb had another one that related to turbine generators. And at that particular time, and partially as a result of that great blackout, there were three or four faculty members at MIT, senior guys, who had gotten an interest in electric power systems. And they had just really gotten started in doing what they were doing.

Sairaj Dhople (00:06:26):

This was the seventies, early seventies?

James Kirtley (00:06:29):

Yes. Well actually, the late sixties. I turned in my master's thesis in the spring of 1968. And that was the day I—very close to that was when I walked into Herb's office. Anyway, he had a project for me that related to using superconductors in generators. And he needed some analysis done, and we set out to—he sent me to doing the field theory associated with electric machines that don't have magnetic materials in them, which involved a whole bunch of partial differential equations: linear partial differential equations. Simple stuff. Well, not simple to—<laugh> But I regarded it as bread and butter. I had just finished taking a subject from Jim Melcher that had a lot of this stuff in it and we set out to do this field theory. And I went to see Herb once a week and show him my work on these partial differential equations. And he kept a copy of it, and his secretary referred to it as, "The Book of Funny Equations." <laugh> So, anyway, there was an experimental program that was—at the time—sponsored by the Edison Electric Institute.

(00:08:20): And we were building a generator, so I helped out with that. And ultimately, a larger project arrived that I think we were sponsored by the Electric Power Research Institute to build a somewhat larger machine, and I set out to build the armature winding of that machine and helped with the theoretical development of the whole thing. And so that was the subject of my doctoral work. And while we were doing this—and this is all biographical stuff—the guys I was working with, Herb and Joseph Smith, who was a director of the Cryogenic Engineering Laboratory—and Joe wound up being my thesis advisor—had caught the attention of people at both Westinghouse and General Electric. This was kind of important to me because after I finished my doctoral work—as I was finishing my doctoral work—Herb left MIT to go to the University of Texas where they made him department head.

(00:10:01): And that opened up a hole in the faculty that my department had to fill. And my graduate advisor at the time—I had a registration officer advisor and a thesis advisor both—my registration officer at the time was Gerald Wilson, who was also a protégé of Herb's. And he said, "You should apply for that job." So, I did, and that's why I was on the faculty at MIT. And I was very lucky because Jerry became department head, and he was department head when a few years later I came up for tenure. <laugh>

(00:10:49): So anyway, that's why I'm still at MIT. So, just to get back to it, the guy that was paying attention to our work from General Electric was Charles Holley, who was at that time director of engineering for General Electric's steam turbine generator department—actually, he was the director of generator engineering. And the guys I was working with had a tradition of going off and working in industry for a while—Herb and Jerry both worked for American Electric Power—so, I decided I'd try and follow that tradition. And so, I contacted Chuck, who I knew because he came over and visited us every once in a while, and offered me a job working in the turbine generator department. And that—so I spent a year in Schenectady.

(00:12:00): And we—I did a number of things for those guys. And I got to know—I think I got to know—quite a lot about turbine generators. <laugh> At one point, I helped them solve a problem that was really pretty prosaic. Their design program was underestimating the excitation requirements for the big nuclear generators—the four-pole machines with six-foot diameter rotors. And so, once I'd figured out what was wrong with the design program—it was pretty prosaic and just hadn't accounted for some slots that were being machined in the pole pieces—I fixed the program. And then they asked me to reevaluate the design of a whole bunch of machines: about 70 big machines. And the director of excitation engineering said, I "cost him $12 million," <laugh> because he had to buy bigger excitors for all these machines. <laugh> But that turns out it wasn't that bad because most of them got canceled.

Julie Cohn (00:13:18):

Oh.

James Kirtley (00:13:20):

This was when people were setting up to build a lot of nuclear power plants. And well, as it turns out, I think we built like two of them; two of the 70-odd. And just parenthetically, if we had built all of those plants, we wouldn't be burning as much in the way of fossil fuels for making electricity. So, that was more or less how I got into the power system business. I was a mild-mannered generator kid, but the big machines that GE was making were connected to power systems. And we did a couple of other things while I was a graduate student at MIT. And early in my faculty career there was another project that was sponsored by American Electric Power to build little model generators to try and verify the simulation routines that people were using. And we built some pretty good models. I superintended the construction of a model of a Westinghouse unit at the Mitchell Power Plant: Mitchell Unit II. And I used to joke with my Westinghouse friends. I'd say, "This was a really good model. It even had a fault in the end windings just like—" <laugh>

(00:14:58): Sorry. <laugh>

Sairaj Dhople (00:15:00):

Was this a physical model or a component?

James Kirtley (00:15:01):

Yeah, it was physical model.

Sairaj Dhople (00:15:02):

And it scaled down by what factor?

James Kirtley (00:15:04):

A million to one.

Sairaj Dhople (00:15:06:

Did you ever connect a bunch of these to—

James Kirtley (00:15:08):

We connected them together. We connected them to the power system. I believe AEP still has one of them that they use for training purposes. We built what we call the Modeled Power System. We had Big Sandy Unit 1 and Mitchell Unit II, and I've forgotten what the other one was. It was a Brown Boveri, a model of a Brown Boveri cross-compound machine.

Sairaj Dhople (00:15:35):

And so, all of these had, like, governors, and you could measure frequency, and all that fun stuff?

James Kirtley (00:15:41):

Yep. We even had a negative resistor that we put in series—I said a negative resistor, I mean an electronics box that emulated a negative resistor—to make the transient time constant of the machine right. We got the subtransient characteristics of the machine pretty good too, so they really did act like they were pretty good models of the power system complex.

Daniel Molzahn (00:16:14):

So down to the fault level? I mean, you were simulating fault. If you're worried about subtransient reactions, you must be running fault studies on it as well.

James Kirtley

Yeah.

Daniel Molzahn

Is that the main application, or—

James Kirtley (00:16:24):

We—it was really an attempt at the longer-term dynamics: the swings and transient stability.

Daniel Molzahn (00:16:32):

Okay.

James Kirtley (00:16:34):

We could do things with these machines that you would never dream of doing with a real machine.

Daniel Molzahn (00:16:40):

Sure.

James Kirtley (00:16:40):

For example, my colleague, Steve Umans, would run this machine with the drive motor acting like a steam turbine. And he'd get it to the point where he'd back off on the excitation, and the machine would go unstable, and then it would catch itself. And you'd get into this operation where it'd slip a pole and then catch, and then it'd slip another pole. Well, we could do things like that with these machines.

Sairaj Dhople (00:17:16):

So, you mentioned swing equations; transient stability. Did you ever have mathematical models that you tried to match what you were observing with this?

James Kirtley (00:17:25):

Yes.

Sairaj Dhople (00:17:26):

Physical?

James Kirtley (00:17:26):

Yes. This was the purpose of this model power system—was not so much that we weren't gonna build a model of the whole power system; we were attempting to verify that models— or help build transient models for these machines.

Sairaj Dhople (00:17:45):

And how many generators and what geographical area was that intended to capture?

James Kirtley (00:17:49):

Well, it was—they were all AEP machines and very limited. I think we only had three units.

Sairaj Dhople

Mm-Hmm. <Affirmative>.

Julie Cohn (00:17:57):

So, this is a judgment question, but today I assume you would have graduate students do this all via digital models.

James Kirtley (00:18:08):

Yes.

Julie Cohn (00:18:09):

Do you think they learn as much as you learned?

James Kirtley (00:18:12):

No. <laugh> Frankly no. I think that it—getting your hands dirty is a real help. And I did in fact manage to get—well, when I was a graduate student, I did a lot of theoretical development, and then I built it.

Julie Cohn (00:18:35):

Yeah. Are there students today who ask if they could do that?

James Kirtley (00:18:44):

Yes. There are some. And some of our—I have had graduate students who built things, probably not quite as—well certainly not as big as some of the machines I built.

Julie Cohn (00:19:04):

So, was there a little control room with some little, tiny people in it? <laugh>

James Kirtley (00:19:10):

No. <laugh> Just racks of electronics. <laugh> So anyway, that's kind of where I came from. And one of the bigger influences in my career—at least with respect to power systems—was another more senior faculty member named Fred Schweppe. Fred, unfortunately, passed away—in, I believe, 1985—so you won't get <laugh> you won't get to interview him. But Fred was a big influence in the power systems. He developed algorithms for doing state estimation in power systems. Techniques that were really the forerunners of the work that—or the functioning of phase measurement units. Fred's stuff would probably be not nearly as required as with PMUs, although I think he helped people understand the physics of how the PMUs work and are helpful.

James Kirtley (00:20:44):

But Fred was leading a group of people—and I was one of those guys that sort of sat at his feet—and we developed a bunch of ideas for how you might operate power systems to make the power systems work better. *[REMOVED FROM TRANSCRIPT]* We were thinking at the time of power systems that were supplied primarily by nuclear generators that like to work on a steady state basis. They like to be baseload, and the question was: could you do something to help the system work more effectively, more efficiently with this constant load?

[REMOVED FROM TRANSCRIPT]

James Kirtley (00:22:34):

We did have several modeling efforts that went on in the laboratory. Another colleague of mine—who was junior to me on the faculty, but senior to me in real-time—John, built a transmission system simulator that consisted of inductors and capacitors. You think about trying to explain how a transmission line works: you draw a little series inductor and parallel capacitors; and we built that physically. And John built this thing and it consisted of several racks with patch camels to connect the series parallel equivalents together.

Daniel Molzahn (00:23:39):

Sorry, I missed it. John, who? Or—

James Kirtley (01:23:42):

Kassakian is his name. John was the founding president of the Power Electronics Society.

Daniel Molzahn (00:23:51):

I see.

James Kirtley (00:23:52):

So, he branched out from the power systems work.

Brian Johnson (00:24:01):

And what about the control systems, were these with op amps, or feedback loops built with analog circuitry?

James Kirtley (00:24:09):

Yes. This was before we had good, convenient microprocessor systems. And so, yes, the controls were analog for that model power system. So, I was getting back to Fred Schweppe, who was the—he was the visionary in the lab. And we—was a group of us, and other prominent members of the group were Richard Tabors, who was now a consultant. We even had, for a while, a gentleman named Paul Levy who was sort of on respite from being a political guy in Massachusetts; he had been associated with Michael Dukakis, who had been governor, and Paul went on to be a hospital executive—but anyway, Paul was around as well So anyway, we developed some ideas, and Fred was really the leader in this group.

(00:25:31): Tabers had some biological background, and he suggested we called what we were doing,

“Homeostatic Utility Control.” The idea was to cause loads to be responsive to the needs of the power system, so you could regulate frequency in part using loads. And there were several different kinds of loads that we were thinking we might be able to modulate to help load frequency control; stuff of that nature. Most of these were Fred's idea. But I was hanging around and we wrote a paper that we presented at the—I believe it was—the 1979 Power Meeting in New York, and the discussion we got was very entertaining.

(00:26:31): A couple of guys from the utility suppliers said, We didn't know what we were doing. <laugh> And I think our written response was rather moderate. We said, Well, we'll see. And fairly recently, utility companies are doing some of the things that we had suggested. For example, there's a company in Boston—I think it calls itself EnerNOC or something like that—that helps utilities. Well, what they do is they get in between utilities and large loads and their bread and butter. The last time I heard about it was water utilities. Water utilities use quite a lot of electricity to pump water up into tanks. Now the trick is, if you pump water up in—if you could modulate your pumping, you slow down your pumps for a while as utility load is going up, that lets them delay having to start to do unit commitment on another unit, and that saves 'em some money. So then when they finally do start a unit, they increase their pumping, so that that unit is now running at higher load capacity. And people make a living doing this.

Julie Cohn (00:28:09):

So, it's like an enhanced demand-side management because you're actually also managing frequency?

James Kirtley (00:28:17):

That's right. And so, demand side management really came—

Julie Cohn (00:28:22):

Out of that?

James Kirtley (00:28:22):

At least I'm gonna claim it came out of Fred's work.

Julie Cohn (00:28:26):

I was about to ask, was this the precursor to—

James Kirtley (00:28:28):

I'm gonna claim that, and I think it probably—I'm sure we had some influence there.

Julie Cohn (00:28:35):

Yeah.

James Kirtley (00:28:37):

Fred had invented this thing he called, “The FAPER: Frequency Adaptive Power Energy Regulator.” So, the idea was you'd pay somebody to have something like this. So, water heater load, for example, you might bias the set point of a water heater based on frequency; so, the frequency went up, the water heater would be more likely to turn on—you’d affect its hysteresis levels. And not too long ago, I had a graduate student do some simulations of a few hundred FAPERs, water heaters run by FAPERS, and doggone if it didn't work. <laugh>

Sairaj Dhople (00:29:26):

So, this sounds like an early precursor to what we now know as droop control for inverters, for instance. Correct?

James Kirtley (00:29:32):

Yeah. Well, droop control—of course—has been around for a long time.

Sairaj Dhople (00:29:35):

Of course. Right.

James Kirtley (00:29:36):

But—we could—you could modify things to make loads do droop control too. So anyway, that—my work in power systems has had a number of different incarnations. And more recently I got involved with—actually, I was collaborating with people in Abu Dhabi at the Masdar Institute, and they supported some of my work. And I built another model power system intended to emulate a microgrid. We just used much more conventional machines, but we could emulate synchronous machines, for example, different loads. And so that was another power systems sort of thing. Most of my research work has been in motors and generators.

Julie Cohn (00:30:43):

So, what would you consider the most important technical problem you've tackled?

James Kirtley (00:30:54):

Well, I'd like to tell you that I have solved some important problems. The one I spent most effort on was turbine generators. And I've worked on both conventional turbine generators—big ones—and machines with superconductors in them. Now, it turns out those have not become items of commerce. We had figured out how to make such machines, but economically, they don't seem to have turned out to be practical. They would've been more practical with really big machines, but then people lost faith in big generators, which would've been nukes. And now generators have gotten a bit smaller in size, and fairly conventional geometries have worked. Something I didn't do, but that major developments in the business have been—learning how to make large, air-cooled machines get rid of the—when I was in the business, the generators were hydrogen-cooled with direct water cooling of the armature windings, hydrogen cooling of the fields and stator cores.

(00:32:54):

And people have learned how to do more direct air cooling, and that makes the machines a lot more economical, and I think in fact more efficient. Not quite as—they get physically larger when that's the cooling mechanism, but that helps 'em become more efficient too. And the rating of the machines is a bit smaller now. I guess you know that many of the gas-fired power plants are combined cycles. They have a gas turbine that drives the shaft, and then they take the waste heat from the gas turbine, run it through a heat exchanger, boil water with it, and run that through a steam turbine, which is usually on the same shaft, and that drives a generator. And those things—I'm sorry, I don't think I could give you a good handle on—but I think they tend to be a little bit smaller. The nuclear machines that I was designing were a gigawatt, or 1.1. I think these machines are more like 700 megawatts or even smaller. I think that's why they're not building superconducting generators. <laugh>

Julie Cohn (00:34:31):

So, did you find that you—throughout all these years you've been collaborating with industrial interests, or has most of your work been in the academic?

James Kirtley (00:34:48):

I've collaborated with industrial people in a few areas but mostly with relationship to motors. I have collaborated with—for example, the copper industry on improving induction motors. I've collaborated with automotive suppliers on motors for electric car propulsion. Earlier in my career, I worked for General Electric, but I also had some collaborations with electric utility companies. And we collaborated with electric utility companies in working with large power transformers. I was part of a group that was interested in monitoring the health of power transformers. And that was supported by industry people. I've had a little bit of government support both domestic, Department of Energy, and foreign. The government of the United Arab Emirates supported the work that I was doing with microgrids.

Unidentified Voice:

Oh, interesting.

James Kirtley:

Not a lot of—well, I also did some work for the United States Navy office in Naval Research.

Julie Cohn (00:36:50):

Are there more applications of microgrids in the Emirates than here? Are they widely deployed?

James Kirtley (00:36:59):

I don't think so. I think their power system is remarkably like ours. They're even building some nuclear generators there. No, it was just the group of people that I was associated with. We had—in fact, one of the senior guys there had worked for Vestas—wind turbine guy. Vestas is a Danish company, isn't it?

Julie Cohn (00:37:34):

Yeah.

James Kirtley (00:37:34):

Yeah. He was an Egyptian and didn't really get along with the Danes <laugh> so he moved back to the Middle East. So, I'm sorry, I'm—where were we going? <laugh>

Julie Cohn (00:37:54):

I just was asking a question that wasn't really related to where we were going, so I was curious about the Emirates; that's all.

James Kirtley (00:38:00):

Oh, yeah. Well, the Emirates is a very interesting place.

Julie Cohn (00:38:06):

Yeah. Did y'all want to circle back to any of the technology?

Daniel Molzahn (00:38:09):

Yeah. So, one question I had on the superconducting machines. You hear more about those used potentially in military applications, in aviation, or these sort of things: Is any of the work that you did with the large turbines being translated into those other applications, or are people kind of—is it a different enough context that it's—

James Kirtley (00:38:34):

I think it is. I know—well, it was the work in superconducting machines that got me involved with the Navy. Because, at the time, they were interested in possibly using superconducting machines to propel ships. In fact, I've had probably a couple of dozen Navy officers as thesis students. And one of them redesigned the Spruance to use the superconducting motors for propulsion, and I think superconducting generators in the drivetrain as well. And he went around this loop of redesigning the ship a few times, and eventually he wound up with three turbine—three generators, and two motors, and each of the generators had a gas turbine engine, so he reduced the size of the propulsion plan by a quarter to get the same performance. So, this was all just design, of course.

James Kirtley (00:40:01):

But that—so anyways. And we've fooled around with that. And that got me into thinking a little bit more about the power systems on ships. And there still is quite a lot of work going on sponsored by the Office of Naval Research into power electronic building blocks. And, of course, maybe the weapon systems on ships have more electrical content now than I did. Just as a side effect, I wound up helping design the electromagnetic aircraft launch system that's on the Gerald Ford: biggest linear induction motors you might ever propose to see, peak power; that thing was a hundred megawatts.

James Kirtley (00:41:07):

You think about it, in order to accelerate an F-18, the flying speed over the hundred meters available, you need a mega-Newton to force. And when the airplane is at takeoff speed, it's going a hundred meters a second. Mega-Newton times a hundred meters per second is a hundred megawatts. Quite something. And anyway, the reason I got involved in that was because I'd had all these Navy officers as students. And there were—at that time when I got involved in—that was more than 10-years ago now—there were four PhDs working for the Naval Sea Systems Command. And all four were my students. Sorry, I'm bragging about things, but that's—

Julie Cohn (00:42:01):

That's exactly what we like to hear. <laugh>

Jim Kirtley:

Okay.

Julie Cohn:

That's what makes it interesting. Did you have other questions about Jim's work with Dr. Schweppe?

Daniel Molzahn (00:42:15):

Yeah. I was just wondering, what was that environment like? So, you had people that were really good on lots of different aspects of the problem, right? And so, did you sort of all bring your own perspective, sit down, and sort of figure out something jointly, or—you talked about Fred being a visionary, was he sort of leading the group, or how did that work?

James Kirtley (00:42:39):

Fred was the convener. He knew he was leading the group. You know that there is no question there; Fred had come from a different background. He was—he came to MIT in—well, he'd been working for Lincoln Labs. Are you familiar with that organization? Lincoln is one of the successor organizations to the radiation lab that developed radar systems during the Second World War. And, of course, the radiation lab was closed right at the end of the Second World War. It had accomplished its purpose, but it was reconstituted. Now this—remember this was all before I was around, so what I'm telling you is what I believe to be true, but I may not get all the details right—but they kind of reconstituted it as two separate organizations: the research laboratory for electronics—which I'm a member of—did the theoretical stuff, and the non-military application stuff.

(00:43:51):

Lincoln Labs was set up, moved deliberately off-campus to take over the more practically oriented things that were going to be done. And it got an—it was mostly working with the Air Force doing radar control. Anyway, so, Fred had been with them, and he was a controls guy, and he was attracted to campus by this group that included Herb Woods and Dave White. These are all very senior guys; none of them are still alive. But Herb and Dave were the core of what they called, The Power Systems Engineering Group. And Fred was attracted to campus, and he was appointed professor with the express intention of getting involved in power systems controls. And I remember he was a little bit more self-assured than perhaps he should have been. And he kind of made some of our power systems friends angry that he—turns out he knew more than he let on about power systems, and he eventually became a very important guy in the business.

Sairaj Dhople (00:45:40):

On what topics did he disagree with the train of thought?

James Kirtley (00:45:46):

I think people just didn't understand it. I think the power systems guys didn't understand it. They didn't really know what he was doing with the state estimation stuff, for example.

Julie Cohn (00:45:59):

So was he bringing a different perspective to it that allowed him to tackle the problem in a way that would've been different in kind from the—

James Kirtley (00:46:08):

I think so. So, I have to admit to you that I don't really know what power systems people knew about the dynamics of their system, but I do know that they were quite deliberately conservative. The notion that a machine's interaction with the power system is inherently stable, you want that to be the case. And so, the power systems guys all wanted the system to be stable. And they thought, or they seemed to assume that if you—the machines were all stable with respect to this larger system, that seemed to be like an infinite bus; that is, there's a lot of inertia out there. If every interaction is stable, and if you're conservative enough in the way you build a system, it'll run stably. Now, the '65 Blackout was—or should of been—a real wakeup call because—and it took years to understand what had happened. And of course, it was a system breakup that involved nonlinearities associated with lines tripping, and other lines getting overloaded and those lines tripping. And I think Fred's view of the world was, Let's embrace the complexity of the system and figure out how it's working. And I don't think that the power systems guys of that era understood that.

Sairaj Dhople (00:48:05):

So, during the '60s, the prevailing line of thought was still doing single-machine infinite bus stability analyses, and then it was after that that the blackout was the turning point when they started to adopt a more network-centric view of these stability problems?

James Kirtley (00:48:23):

I don't think so. No, I think it took them longer than that to understand.

Sairaj Dhople (00:48:31):

But did the attempt start after the blackout, you think?

James Kirtley (00:48:33):

Oh yes, I think so. But if you think about where—the academic world was ignoring power systems. Really. I remember my undergraduate advisor saying, “The good people go into electronics and the duds go into power systems.” <laugh> I said it in almost that many words, <laugh> and I think academics across the country thought that too. And well, we've lost some really important guys over the last few years. And I think that those people were all the same generation as the people that I'm talking about, the senior leaders—senior to me—Fred and Herb; Dave White and so forth at MIT; Pai; and, of course, Pete Sauer was my generation, almost exactly my age. But there were more senior guys at those schools. I'm thinking Bob Thomas at Cornell, for example. And, if you look around the country, you'll see—so, I'm thinking about Paul Krause at Purdue. I think the—there's a generation of people that were attracted into thinking about this and the academic world did start thinking more about power systems after that blackout in '65.

Sairaj Dhople (00:50:27):

But why do you think there was this negative connotation towards power engineering back then?

James Kirtley (00:50:37):

I dunno. I think it was regarded by electronics people as being big iron and copper.

Julie Cohn (00:50:49):

Do you think there was a misapprehension that by the early 1960s, surely everybody understood everything they needed to know about how it worked?

James Kirtley (00:50:59):

Yeah, I think so. <laugh> Until it didn't.

Julie Cohn (00:51:06):

Yeah. <laugh>

James Kirtley (00:51:08):

Yeah, I think that's probably the case. Gee, one of my mentors at MIT that I haven't mentioned was Charles Kingsley. And Charles was so lightly regarded that he retired as an associate professor.

Sairaj Dhople (00:51:26):

Author? Wrote the famous book?

James Kirtley (00:51:28):

Yes.

Julie Cohn (00:51:32):

What's the name of the book?

James Kirtley (00:51:34):

Electric Machinery.

Julie Cohn:

Oh.

Daniel Molzahn (00:51:38):

<laugh> Remember that book?

Daniel Molzahn:

So, one other question I had on the state estimation side was: so, Fred was coming out of this controls community—did they have a good sense of the controls community at the time of state estimation? And this was a relatively well-established technology and other domains besides power, and he was bringing it into power systems, or was it that this just didn't exist anywhere and doing state estimation was just kind of this novel idea, period?

James Kirtley (00:52:09):

That's a good question. You know, I'm sorry. I don't know. I would guess that controlling radars was complicated enough that it probably did involve—I'm sorry. Well, we think about when we're doing simulations, for example, what you do is you have a collection of states—the state of something— and I'm sure controlling radars to look at, to track incoming missiles, for example, that's gotta involve some understanding of states in the system. So yeah, I think that is very likely. But we did simulate single-machine infinite bus interactions. And, you think about that, one's got about seven states.

Daniel Molzahn (00:53:12):

When you were building these model power systems, were you thinking about that as, I'm setting up these states in the system, or were you thinking, I'm building this hardware that—

James Kirtley (00:53:20):

I was thinking we're building this hardware, and we want it to look like a real machine.

Daniel Molzahn (00:53:27):

Mm-Hmm. <Affirmative>. So, is that maybe why the group was so productive? You had people with— you had this hardware experience, I'm gonna model this real machine. You had people thinking about the kind of theory, and more of a controls perspective.

James Kirtley (00:53:39): I think that's right. We had a couple of hardcore hardware guys like me and then theoretical guys.

Fred was— Fred would never get his hands dirty. <laugh> He didn't even program a computer. He'd get his graduate students to do that. <laugh>

Daniel Molzahn (00:54:01):

So, do you think that has—I don't know if this is your plan for next steps, Julie—but do you think that has implications for as we go forward? What's the right mix of people that we need to try to tackle these problems in the future? And do we have that—are we here with that mix of people, or is there, at the general meeting, or we need to bring in more? Is there somebody missing from the conversation?

James Kirtley (00:54:26):

Well, obviously I'm gonna tell you, you need more hardware people like me. <laugh> But I can't tell you that I know that for dead certain. I mean, at some point you've gotta build hardware; our systems are big collections of hardware. Now, you still have to understand them, and that—and you definitely need theoretical people to understand them.

Julie Cohn (00:55:05):

In a slightly different direction to go in, I understand you were—I'm gonna get the title wrong, but you'll correct me—you were in an editorial role with the Transactions of the IEEE?

James Kirtley (00:55:19):

Yes.

Julie Cohn (00:55:19):

What was your title?

James Kirtley (00:55:21):

I was Editor in Chief of the Transactions on Energy Conversion.

Julie Cohn (00:55:25):

Okay. So, my question to you—beyond the title—<laugh>

Jim Kirtley:

Yeah.

Julie Cohn:

How did you—did you observe controversial theoretical matters or even competing ideas about correct design play out in those transactions?

James Kirtley (00:55:54):

Yeah, I think so. I participated before I was involved with the—before I was an editor, I participated in some controversial stuff. <laugh> And it was—I guess it was because I had maybe a deeper theoretical understanding, but a bunch of guys, including a couple of people I knew, proposed a model—a simulation model actually—for turbine generators that involved putting an inductor in the middle of a cut set of inductors. And I looked at that and I said, “Wait a minute, that doesn't change the number of states.” The direct axis of a turbine generator is inherently—well, depends upon how many parallel branches you put in it, but it's third order. And these guys wanted to make it fourth order. But I raised my hands. They blew me off. That is where they presented this at a meeting, one of the predecessors of this meeting. So, I went off and wrote a paper telling 'em that they took their model with the inductor in the middle of a cut set and translated it into a more conventional model. So, we got into fights. <laugh> They didn’t like it. <laugh>

Julie Cohn (00:57:42):

So, was that an example of a series of publications that threshed out?

James Kirtley (00:57:47):

Yeah, yeah.

Julie Cohn (00:57:49):

And did everybody reach consensus at some point, or is there still a division of opinion?

James Kirtley (00:57:58):

I don't think so. I think cooler heads prevailed. There was a little bit of additional discussion. I published this paper that appeared in the “Transactions on Energy Conversion,” and that drew some further discussion.And there was a couple of guys from Lavalle University. Innocent Kamwa was one of them. And I'm sorry, I've forgotten the name of the other guy, but Innocent's here; he's taken a major role in the society. Anyway, they said effectively, Kirtley's, right, but—<laugh> and then they explained why using this additional element might be appropriate. And I think I understood what they were saying because if you want the leakage branches to be the same for both axes—which seems like the right thing to do—you need something else to trim up the direct axis. And I'm sorry, I'm talking rather jargonish terms here. I think that was what they were saying. So, ultimately—maybe one way or the other.

Julie Cohn (00:59:34):

Was this something that was later effected in physical machines or systems?

James Kirtley (00:59:45):

I don't think anybody uses the model that these guys propose. I think everybody uses the more conventional model.

Julie Cohn (00:59:52):

Okay.

James Kirtley (00:59:52):

In which the two leakage elements may not necessarily be the same. That was a minor controversy. While I was editor-in-chief, I did a few things that wound up getting me kind of in hot water. <laugh>

James Kirtley (01:00:10):

I rejected papers that all reviewers thought should be published, and that caused me some grief, but— <laugh>

Julie Cohn (01:00:24):

Well, I think I was just curious about how these ideas are negotiated in classrooms, at conferences, in publications, in the real world when people buy products and put them to use in power systems.

James Kirtley (01:00:43):

Yeah. One thing that I think we've lost in the Society—are we running over?

Julie Cohn (01:00:50):

We've got more time.

James Kirtley (01:00:51):

One thing I think we've lost in the Society is the practice of discussing papers. When I was a junior guy around here: we present a paper and people could get preprints of the papers. Very often, there would be people in the crowd who had read the paper, and sometimes they'd come with a written discussion of the paper. And for example, when we presented this paper on homeostatic utility controller, a couple of guys came up with written discussions. And then the author would have the chance to write a closure, a rebuttal, to the written discussions. I kind of miss that because it does go in the direction of hashing out our differences and arriving at a negotiated settlement. <laugh>

Daniel Molzahn (01:01:58):

Did you have a sense of why—where that stopped and why it stopped?

James Kirtley:

I dunno.

Daniel Molzahn:

You certainly see it with older papers. And then sometime it seems around eighties or so, they become less common.

James Kirtley (01:02:12):

Yeah, it— I'm sorry; I have never been involved in organizing the annual meeting or the summer or winter meetings. And I really don't know where the written discussions went away. I can't even remember when they went away, but I think it was unfortunate that they did.

[REMOVED FROM TRANSCRIPT]

Sairaj Dhople (01:02:48):

How long did you serve as editor?

James Kirtley (01:02:51):

Too long. Longer than I should have. <laugh> I'm not sure that the rules had been hashed out. The—when I first joined the IEEE, there was one publication of the Power Engineering Society, which was *Transactions on Power Apparatus and Systems*. It was a monthly—and it was a fairly thick Transactions. At some point in the nineties—I believe—the decision was made by the publications board to split that into three Transactions, and so, there was: *Energy System*, *Energy Conversion*—I'm sorry, it was one; *Power Systems* was the second; and *Power Delivery* was the third. And they are still published; one of them each month, each of the three is a quarterly. And there was one editor fellow named Hal Gold, and I guess along about the time that Hal decided to retire—I'm guessing this—it was decided that they needed to have somebody to do each of the three. And I was the first editor-in-chief of the Transactions on Energy Conversion. I was recruited to that job by Mel Olken Power and Energy, or Power Engineering Society at the time. So, I started doing this in 1998.

James Kirtley (01:04:46):

I think I have a year right. Along about 2006, somebody pointed out that editors-in-chief were supposed to have three-year terms <laugh> with the possibility of one renewal. <laugh> And so, the guy who was vice president for publications at the time, Manny Venkata, called me up and told me about this, and I said, “We better fire me, haven't we better?” <laugh>

James Kirtley (01:05:17):

So, we recruited another guy to be editor-in-chief, so that was that. So, I did it for eight years, and I should have done it for six. <laugh>

Julie Cohn (01:05:29):

We're closing in on the end of our time, so I wanted to see if there were any additional technical, technology-specific questions you had. I have a future-looking question, which we've sort of talked about a little bit, which is that you've been involved in addressing a variety of technical problems that apply to motors and generators on the grid today. We're looking ahead to a different kind of grid in the future from what I understand: do you think the solutions that we have today are appropriate for future power systems?

James Kirtley (01:06:15):

No. <laugh> I'm sorry. I have definitely been involved in solar energy. We haven't talked about my life in that business, but I took a couple of years off from MIT to run a piece of a little company in Cambridge, and we got acquired by some vulture capitalists, and we became a large manufacturer of power electronics for solar systems.

Julie Cohn (01:06:53):

Oh.

James Kirtley (01:06:53):

So, I have some experience in that field, and I've done a bit of work with wind turbines. I can't tell you that I've really built—I've built a prototype of a weird machine that in retrospect is not suitable for wind turbines, but I had some sponsorship from NREL to do that too, so I know a little bit about those. And frankly, I think that this notion of relying on renewables—wind and solar at least—is not gonna work. I think we're going to have to make a transition to nukes. I think ultimately, we're gonna find that we need more nuclear power plants—and so I'm gonna sound like a crusty old guy, which I guess I am—but I think we need to go back to a more traditional system. Rotating machines have a very substantial stabilizing influence on the power system.

James Kirtley (01:08:14):

And I see some promise. There are quite a bit of activity in people developing new kinds of nuclear plants—safer plants, that is plants that don't offer the prospect of melting down. And I was looking at a website today of somebody, somebody that wants to rejuvenate liquid metal-cooled fast breeders. Well, I hope they know more about seals than the last round. <laugh> But anyway, this is my personal opinion, that's where the system ought to be going. And that's not that I don't have fondness for solar and wind, but—

Daniel Molzahn (01:09:02):

Do you think if we move in that direction, is it important then to bring back this load control? As you mentioned we talked about load control or frequency control before, does that become a bigger player in the future then? Is that—?

James Kirtley (01:09:17):

I don't think so. I think if you had a system that was dominated by renewables—that is solar and wind—you're gonna need load control even more because the solar and wind are hard to control, so you're gonna need load control to help keep the system stable. I don't know, but I have a feeling that especially these smaller modular nukes are probably better at load following than the big ones. That's a guess. So anyway, that's my opinion. And I'm sticking by it. <laugh>

Julie Cohn (01:10:01):

Would you like to give the final question?

Sairaj Dhople (01:10:03):

Yes, any words of advice for the next generation?

James Kirtley (01:10:11):

Boy, talk about a curve ball. <laugh> I—there'll be no one—

Sairaj Dhople (01:10:18):

Build things. <laugh>

James Kirtley (01:10:20):

Yeah, well, I think I've already said that. <laugh> The next generation of students—at least my students—are more theoretically adept than I was. They don't—they haven't built as many; they don't build as much. And that's as much my fault as anything else. I do have to say that over the past several years I've had students that did build things. And I think that's—I think we need people with a broader range of interests, than many of the people we have. But if you're gonna work in electric machinery—as many of my recent students have—you kind of have to have a fairly broad range of interest. Because you make electric machinery, you need to work with metals, insulating materials. There's some chemistry in it; there's heat transfer. A bunch of things need to go into those kinds of machines. And I think I would agree that that power systems needs a broader range of people or a broad range of it. I can't say comparatively to what we're doing now.

Julie Cohn (01:12:01):

Great. Thank you. We really appreciate that you took time to join us during this very busy IEEE-PES general meeting, so thank you for doing that.

Daniel Molzahn (01:12:12):

Thank you so much. We very much appreciate that.

James Kirtley (01:12:14)

Enjoyed the speed of the discussion. Thank you.

[End of Interview]