Algorithms & Power Systems Architecture:

Using Historical Analysis to Envision a Sustainable Future

Oral History Project

Interviewee: John McDonald

Interview Date: January 25, 2023

Place: Georgia Institute of Technology, Atlanta, Georgia

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

Transcriber: Temi online

Keywords: John McDonald, Ahmed Hanafy El-Abiad, electrical engineering, digital computing, Purdue University, nuclear power, Brown Boveri, ASEA, supervisory control and data acquisition (SCADA), SCADA Automatic Generation Control (SCADA AGC), FORTRAN, Westin Engineering, Bonneville Power Administration, William (Bill) Tinney, sparse matrices, Muscatine Power and Water, PTI Consulting, Energy Management Systems (EMS), Distribution Management Systems (DMS), droop control, Advanced Control Systems

Abstract**:**

Mr. McDonald describes his educational background at Purdue University and UC Berkeley, his work for Brown-Boveri company in Switzerland, development of a SCADA system for power applications, and additional professional experiences. He describes meeting and marrying his wife and starting his family. He discusses transitioning away from analog programs and using early digital computers. He mentions competing consulting firms and several utilities with which he worked. He discusses collaborating with Bonneville Power Administration and the trend away from industry-based research. He discusses at length SCADA AGC development, and its impact on cost to customers. He mentions the “hiccups” of the first implementation on the Muscatine Power and Water system. He describes the real-time demands of Automatic Generation Control (AGC). He continues with discussion of licensing the SCADA AGC system to other consultants and to utilities. Mr. McDonald describes sparse matrix theory, power system modeling, and energy management systems. He reflects on the impact of his master's thesis on the industry, especially on the distribution side. He closes by reflecting on 48 years working at 6 companies

in the industry, 52 years as an IEEE member, and encourages young engineers to always take the challenging route.

<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 (00:00:02):

My name is Julie Cohn and I'm conducting an interview with John McDonald on Wednesday, January 25th, 2023, at the Georgia Institute of Technology in Atlanta, Georgia. Daniel Molzahn will assist with the interview, and Rachel Harris is also participating in this interview and may ask questions. John, today's interview is focused especially on your work in power systems modeling and three-phase load flow modeling and how it was later carried forward into energy management systems. But we're also interested in just learning a little bit more about you generally. So, before we get into any technology questions, please briefly describe your educational background, your professional positions in the field of power systems, and any other tidbits you think would be interesting.

John McDonald (00:01:17):

I knew I wanted to be an electrical engineer from about age 10 on.

(00:01:26): And I don't know how this happened, but for my birthday and Christmas, I always wanted Radio Shack booklets on electricity. My parents would buy those, and I taught myself electricity, taught myself how to solder, and all my birthday gifts were—I made a short-wave radio, walkie-talkies, code oscillator. And I was building electronic kits at like fifth, sixth, seventh grade, so I really, really enjoyed that. So, when I went to Purdue, I had an Illinois State scholarship growing up in Chicago suburbs. My folks wanted me to go to University of Illinois so they could save some money. My dad, my mom, my brother, my sister, and I all born in Indiana. So, we're all native Hoosiers, but we were living in the Chicago suburbs. And my dad and I visited Purdue first before Illinois, and I fell in love with Purdue.

(00:02:23): So, we paid out of state tuition, <laugh> as native Hoosiers. And I went to Purdue as an electrical engineer. So, I had taken a lot of calculus and honors classes in high school. So, I started as a second-semester freshman in the honors program in electrical engineering at Purdue. And so, I started taking electrical engineering courses in my freshman year, which was good. But life-changing for me was a professor at Purdue who—I was just first year, trying to get through the curriculum—asked me to come to his office. And so, I was very surprised. I went to his office. It was Professor El-Abiad, who I didn't know. But he—I sat down and he being—was Egyptian and very dynamic and forceful personality.

(00:03:26): He basically says, "John, you will be a power engineer," not "Do you want to be," he says, "You will be." He said, "You're in the honors program. So, I have complete flexibility on your curriculum. You'll take all the power courses; Purdue has a good power—you'll start graduate school in your third year and do undergrad and grad at the same time. You'll do a bachelor's, master's with a full thesis in five years instead of six. You'll take a mechanical engineering fourth year course on, on energy balance without the thermodynamic background that the mechanical engineers have. You have a crash course in thermo- for one semester, but you're going to compete with all of them," which I found out later I would be doing, and two nuclear reactor graduate courses on how to design nuclear reactors without any of the undergraduate background.

(00:04:22): 'Cause he said, "My vision for a power engineer is electrical, mechanical, and nuclear." This was in 1970, 1971. So, I later find that this guy had just co-wrote the first book in our industry in 1968 with Glenn Stagg. So, Stagg/El-Abiad, *Computer Methods in Power System Analysis*, the first book in our field with flowcharts. How do you model the power system with a digital computer? Never been done before. Y-bus, Z-bus, FORTRAN programs at the time. He was the guy who saw me <inaudible>asked me to come to his office, and basically the rest of my life was told—I mean, my career—what I was going to be doing. And it was a very challenging curriculum. And at the same time, I'm pledging a fraternity—spring of 1970, my freshman year—moving, living in a fraternity house with a very active social schedule, a lot of leadership positions in the fraternity, working at Purdue Food Service, driving food trucks, and serving food to graduate students in the graduate house.

(00:05:46): So, it was a good lesson for me on time management: how to manage my time, do well, but get everything done. So, I've specialized in power in a big way. I took probably more power courses at Purdue than any other student, because of the flexibility of my curriculum. But I received some very wise counsel when I interviewed, I had work experience in downtown Chicago all throughout my five years at Purdue. I was doing work for an architect engineering firm—the mechanical engineering partner of that firm is Consoer Townsend & Associates. The mechanical engineering partner was a family friend of ours at church in Arlington Heights, Illinois—where I grew up, the suburb of Chicago.

(00:06:43): And my folks said, Hey, John's a freshman at Purdue; after his first year do you think he could work at the company in downtown Chicago? And so, mechanical engineering partner—his name was Carl Bowen—talked to Fred Sanneman, the electrical engineering partner, and said, “Yeah, sure." So, I was really lucky that after my first year at Purdue, I'm taking a train with my dad every morning downtown and doing engineering work. And it was the power distribution and controls for wastewater treatment plants. And back then, in 1970 there was no computer-aided drawing or anything, so I had a parallel T-square that went up and down on cables. And I drew every floor of every building; laid out all the power distribution, all the control; coordinated with mechanical on the duct work for HVAC; and brought power to all the HVAC equipment, the controls, piping.

(00:07:56): I did all that after my first year at Purdue; fantastic experience. And I found that I was so excited about the work they were giving me more and more to do, and I'm getting paid for overtime, and I'm much more productive than any of their full-time people. <laugh> So, you're naive as a student, and don't realize that these full-time people are looking at you. And you're just cranking out the work and liking it, and they're kind of coming to work every day. And then there was another guy there who was at Purdue who was on the co-op program. So, he—it just so happened—co-opped there. So, we became close because we were both EE's at Purdue. And they had a wastewater treatment plant in Erie, Pennsylvania.

(00:08:48): And the as-built drawings were way out of date that before we could do updates to that plant, we needed to update those. And all of a sudden, the leaders of the company send these two college students <laugh> on this trip. And the full-time workers are saying, We've never been on a trip for the company, and these two summer guys are going. But we did great work, got it done quickly. The leadership liked what we did, so it was a great experience. When I interviewed—at the end of my master's degree, I interviewed 18 companies. And all 18 gave me offers and interview trips; didn't get turned down by anybody. But the one was Bechtel Corporation in San Francisco, architect-engineering company, very similar to what I was doing in Chicago. So, the fellow that came on campus from San Francisco, Mike Lossner—great guy—said, "You could be productive from day one with all the experience you have, but you would think that being a power engineer, you would go to the power division at Bechtel.

(00:09:55): But I counsel you not to do that. I'm in the mining and metals division. You should go into mining and metals, still do power distribution and controls," like I was doing for water and wastewater treatment in Chicago. I'd be doing it for mining and metals facilities. He says, "Here's why you should do that. You get onto these power plant projects—" And this was the heyday of nuclear because this was 1974 before Three-Mile Island, and we had 12,000 people in downtown San Francisco, and most of those are working on designing nuclear plants. "You get on one of those projects, you're young and you're on that project for 10 years. You don't want to do that as a young person. You want to get on a project, finish the project, and get on a different project. And our mining and metals projects are like a year, year-and-a-half." I was lucky with El-Abiad to get his direction and his counsel. I was really lucky with Mike to get—So I went into the Mining and Metals Division, and I was working on projects and doing all the technical studies—as a 22-year-old—on these projects and meeting with clients and presenting the results with more senior people in the company. So, it was a great experience. And then I always wanted to get an MBA.

(00:11:20): So, I had a bachelor's and master's in electrical engineering and power. But I still feel today, and I counsel young people, that a good engineer needs to understand the business side of technology. Because through my career, I've seen many good engineers with fantastic ideas for projects, but they don't get them approved by the senior management of their company because they can't express the project in a business case. The senior executives don't want to know the bits and the bytes and that stuff, but they say, What's the cost, how many years before the benefit curve crosses the cost curve, what's the payback period, what's the benefit-to-cost ratio? Or in power systems, they'll say, For every dollar I spend on your project, how many minutes of SAIDI will you save me—in other words—for every dollar I spend on your project, how will you improve the reliability of the grid, or for every dollar I spend on your project, how many millions of tons of carbon dioxide will you prevent from going to the atmosphere? By adding automation in the substation, you're reducing the number of truck rolls—number of times trucks go out to the substation—and you can calculate how much CO_2 you're saving from the trucks. And you're helping the environment. So, the—you got to think about your project differently.

(00:12:39): And so, I found that the University of California Berkeley, one of the top five programs, I think in the country for an MBA, had a special evening program in downtown San Francisco for those of us that worked during the day. And the professors loved to teach us, because they could get a lot of our work experience. They got so much feedback on their research from all of us who were working during the day. And we had classes at Hastings Law School, Berkeley's Law School in downtown San Francisco, so it was very convenient. I had class Monday night, six to nine; Thursday night, six to nine; and it was a full two-year program that I finished in three-and-a half-years by taking two courses a quarter. And it was the best and specialized in finance.

(00:13:32-00:14:01)

[REMOVED FROM TRANSCRIPT]

John McDonald (00:14:02):

So, when you finish all your initial goals that you had set, question is: what do you do next? And for me, that was June of 1978. All my initial goals had been achieved. I knew I'd probably change jobs. I'd been at the same company four-and-a-half-years, but I didn't know what I was—; my whole life had been so structured. When you're working 50 hours a week during the day engineering, you're going to— Taking the MBA at night, two courses a quarter; played third-base on a fast-pitch softball team; coached one of six flag football teams and played—we had games every Sunday; built my own stereo at the same time—Dynaco had kits, I built an AM/FM tuner and a power amp.

(00:14:58): So, I'd fire up my soldering gun at maybe midnight, one in the morning after my MBA homework, and it was just very, very relaxing for me to do soldering for a couple hours before going to bed. So, when I graduated, I had saved up a tremendous amount of money <laugh> because I had no time to spend it. So, I took an official leave of absence from Bechtel, flew to Amsterdam, landed early in the morning, and had a car waiting for me. I prepaid three months unlimited mileage, and I didn't know where I was going to stay that night. I said, "I want three months of unstructured living just—And I'm going to spend every cent I've saved and just have fun." And so, that was very unusual at the time to do that. <laugh> The approval cycle of Bechtel to get this leave of absence approved,

(00:15:53): every step, the senior executive would call me and say, "Are you serious?" 'Cause the form said, why do you want a leave of absence? Death in the family, personal illness, all these disastrous things. I said, other, <laugh> travel through Western Europe. So, that's what I did, and it was the best thing I did. I needed no structure for three months. I spent every cent I had saved <laugh> and I had a great time. So then, I came back, and it turned out then that leave of absence—nice thing was I came back and had a job; so, I came back to Bechtel. But one of the very experienced guys I worked for at Bechtel, he was—lived in Palo Alto, and he was in his backyard watering his yard.

(00:16:42): And his neighbor had founded a SCADA company 10 years before in Santa Clara, California with Philco Ford and had just been bought in September of '78 by Brown Boveri. This was before Brown Boveri and ASEA came together. So, Brown Boveri headquartered in Baden, Switzerland, and had just bought the SCADA company in Santa Clara, California because they wanted to get into the US and SCADA. And Brown Boveri, a power engineering company, said to Herb Nyser—Herb was the founder and CEO and the neighbor of a fellow I worked for at Bechtel, the leader of Brown Boveri in North America said—"How many power engineers do you have in your company?" And Herb, after 10 years of doing SCADA work, said, "None," because he did very vanilla, very generic SCADA. A point could be water, it could be gas, it could be electric, but there were no applications that took it into electric or took it—; it was basically acquiring data and doing remote control.

Julie Cohn (00:17:52):

Can you explain for perhaps an imaginary class of freshmen English literature students at a smart university, what SCADA is?

John McDonald (00:18:05):

Yeah. I say SCADA is the platform for all automation. If you're going to do any kind of automation you need to be able to acquire data from the field; do remote control, instead of going to the substation; be in a control center and office; and be able to remotely control equipment. And the SCADA system has three parts: a master station; some control center, field equipment that gathers all the points in the field; and the most important part, the third part is the communications, that's like the glue that ties everything together. So, the field equipment is collecting data, sending it up to the master station; the master station, you're processing it; you could do different analytics to it, but also you have color user interface; so, you can have schematic diagrams to see what's happening; and you do the remote control through the displays.

Julie Cohn (00:19:11):

And what does the acronym stand for?

John McDonald (00:19:13):

So, supervisory control, SCADA, S-C-A-D-A: Supervisory Control and Data Acquisition.

Julie Cohn (00:19:22):Carry on. <laugh>

John McDonald (00:19:24):

So, Herb said, “This leader of the new parent company”—of his new parent company—“how many power engineers do you have?” And he said, “None." And they said, I think it'd be good for you to hire some. So, Mike—the fellow I'd worked for at Bechtel, the neighbor—said, “I've got just the person for you,” and that's how I was recommended. And so, I interviewed—so I was living in San Francisco—this was in Santa Clara, down the Peninsula. And this was good for me because I interviewed—and I'd never done SCADA before—but I had a strong power system background, which is what Herb needed to show Brown Boveri. And Herb—Back then, I think you found more older executives like founders of companies who were very old school in a sense.

(00:20:33): It wasn't how hard you worked during the day, what was important to him was that you were there at eight o'clock in the morning in your office, and that you didn't leave until five o'clock in the afternoon. And when he walked by your office, you weren't goofing around, but you were working. Because he'd take his coffee cup and he'd walk around at eight in the morning to see who was there. So, after the interview—I found this out later—everybody I interviewed at the company loved me and wanted to hire me, and Herb was afraid I was too young. Just—He was just looking at age, not background or anything else. And fortunately, everyone on his staff said, No, forget the age, this guy could help us.

(00:21:21): And they hired—I joined in 1979. So that was—it's an area of specialty for me. Now, I have a book I've co-authored called *Power System SCADA and Smart Grids,* and so, it's an area of specialty for me. But that's how it started, in 1979. And what was good was at the end of a year, my manager all of a sudden left engineering and decided to be an executive recruiter, which was totally— We didn't expect it. And the president and founder of the company asked me then to take over to manage that group. And I was—1980, I was what, 28, 29 years old—never had a management position before. I was managing people now that were much older than I was. And true in California too, the lifestyle is very different from the Chicago suburbs where I grew up.

(00:22:27): Everyone in my group had been married and divorced at least once at that point. And I had—And also one of my best friends at the company, his ex-wife had married another fellow in our company, so we would get together socially. For me being—growing up in the Chicago suburbs—very conservative, it just—it was funny. We get together socially, and here's my friend with his new wife, two young boys, and his ex-wife was there with her husband who worked for our company. So, this was—I'm managing a group, and it was a great experience for me at a young age. So, I was there three years. And then the main thing that happened in those three years was I met my wife on an airplane. I was coming home from a business trip, and we sat next to each other in June. First date—July, engaged in August, and married in November. So, I was in the peak of bachelorhood and then like married a couple months later. It was crazy. But I always tell the young people, "The best things happen in your life when you least expect it. If you look for it, it's never going to happen, like a watched pot never boils."

Julie Cohn (00:23:49):

Right. Yeah.

John McDonald (00:23:50):

So anyway, we got married, our daughter was born in San Jose. My wife's from Chicago also, so we said, Raising a family out here in the Bay Area is crazy, we can't afford it, and we want to provide our kids the same type of house, schooling, and stuff that we had. So, we sold a townhouse we had bought for $90,000. I made $15,000 in14 months: thousand square feet, sold it for $90,000 in early '82; moved to Pittsburgh, Pennsylvania in Upper St. Clair in the South Hills, which is a very nice suburb to raise a family in; and bought a 2,500-square-foot four-bedroom home for $79,000. So, I had two-and-a-half times the space, big yard for swing set, sandbox, good schools, and $11,000 leftover. <laugh>

Julie Cohn (00:24:42):

So, I'd like to just back up briefly to the SCADA company, Brown Boveri's work.

John McDonald (00:24:50):

Yeah.

Julie Cohn (00:24:50):

What was happening on power systems that made this an important project to tackle?

John McDonald (00:24:57):

In fact, this gets into—this is a very good question, Julie, because not only had I not gotten into SCADA before, but after I was hired—right after I was hired—the president of company looked at me, he said, We proposed a million-dollar system; which is huge in 1979, but it was the first time—and you'll like this—we'd ever proposed a SCADA AGC system with four application softwares: automatic generation control, economic dispatch, interchange scheduling, and interchange evaluation economy A—, we had economy A and economy B. Economy A was short-term, real-time. Economy B was looking out hour-by-hour in the future and evaluating future transactions. And I looked at Herb. <laugh> I said, "You don't have that software; how did you do the proposal?"

(00:26:05): And well, we took sections of what other companies had written—which shouldn't be done—but this was before I joined the company. And we wrote proposal material about these four power applications and submitted it, and we made the shortlist with this very well-known industry consultant in Los Angeles, in Tustin California. The consulting company was ECC at the time—or no, Weston, and Dennis Gaushell. And I forget this, but anyway—Herb looked at me, he said, “You're our new power engineering expert. We have a meeting with this experienced consultant next week in LA, and you're our expert on these four power applications.” I said, “I don't and I'm just learning SCADA <laugh> let alone the details of automatic generation control, economic dispatch, four applications.” And we don't even—the company doesn't have the applications, and there's no internet back then. How do I find out information—go to the library? Am I going to find in the library a detailed book on AGC, or these applications? The IEEE had a tutorial at the time on power applications—which I was able to get a hard copy of very quickly—but I had a week to basically know this and be in front of a very experienced industry person as a consultant who was going to make a decision on a million-dollar project that—talk about pressure. So that—

Julie Cohn (00:28:04):

So, was it the case that the kind of computing systems industry was using in the—this was the mid-to late 1970s, correct? Announced late 19—

John McDonald (00:28:14):

Yeah. This was around 1979.

Julie Cohn (00:28:17):

So, that was when the industry was kind of completing a transition toward digital computing from analog computing. But were there machines that were capable of doing these multiple tasks at once, or was that a novelty?

John McDonald (00:28:33):

What you had to do was you had to—there were no machines that were—at the time—specialized in real-time multitasking operating systems, not until HP's PDP11—I mean, I'm sorry—H- HP's real-time operating system. What we were using at the time was—most popular was the DEC, Digital Equipment Corporation, PDP11. And we bid the job before I joined the company. They bid the job using PDP1160s, as the platform, dual-redundant for reliability. And the challenge back then was you were lucky to get 500 k-bytes of main memory. Memory was—a disk drive was huge, and very heavy—it was a platter.

(00:29:48): So, you had to be—when you programmed, you had to be very efficient with programming, and you really had to be optimized with your code because you didn't have special real-time multitasking operating systems. I didn't see that until I worked for the SCADA company when I moved to Atlanta in 86' and started working for advanced control systems; we were using the HP family of real-time minicomputers—did we have an operating system that was really optimized for real-time multitasking situations! So, this was on a PDP1160, so we had—so anyway, we had the meeting, and we won the job. So now I had an 18-month schedule. We had to deliver the system, and we had <laugh> no software applications. So, I went to Switzerland, and I thought, okay, our parent company who's world-renowned in power engineering. So, I worked in Baden for a while and really looked at the source code of the applications there, and just—to some extent, or to a great extent—the code was not the latest and greatest code; it was digitized versions of old analog algorithms.

(00:31:22): I hate to say this, but I couldn't have taken this code and been successful in the US. With the scrutiny that consultants, in the US, North America—these consultants that were writing the specs and evaluating, been in the industry for 30, 40 years, and in operations, software, and all these applications—they would ask very detailed questions, and you want to tell the truth. So, I came back from Switzerland, and I told Herb, “We can't use the parent software. It's just—I won't be successful in North America. What do we do?” So, I was fortunate that I found out that Power Technologies Incorporated, PTI, in Schenectady, New York, was founded by GE folks:

(00:32:31): Lionel Barthold and Bob Ringley; Bruce Wollenberg. A who's who in our industry with power applications. A guy named Joe Denison there, and Eric Scott, they had just written, unbelievable, four FORTRAN programs to run on PDP1160s for Toledo Edison. Unbelievable. I couldn't believe it. It was exactly the applications I needed, the same computing platform that I needed, and a very reputable company. I mean, you take an economic dispatch program written by Bruce, or you—I mean, these are the folks that wrote the books and teach the courses at universities about this stuff. So, I flew out to Schenectady and started negotiating—and remember now I'm like 28-, 29-years-old with like the icons in the industry negotiating—and desperate need for these four applications. And so, it was just beautiful because it was a perfect match. We were really lucky. So, we liked—

Daniel Molzahn (00:33:57):

Can I ask you a follow up on that?

John McDonald (00:33:58):

Yeah.

Daniel Molzahn (00:33:59):

So, do you think that was chance—that it just so happened that the applications that you had put in the proposal were this—or that the company had put in proposal were the same ones that Bruce and other folks were developing, or was there something else going on at the time that made it so that those were what was needed and not something else?

John McDonald (00:34:19):

I would say, in a sense, it wasn't. It was a little bit chance, but in a sense, the four core applications for a SCADA AGC system at the time. I mean, if you were going to move from SCADA to SCADA AGC—which Toledo Edison was doing, and Muscatine Power and Water in Iowa, who we got the contract for was doing—the four core applications that you would want would be these four. So, Toledo Edison hired PTI to write those applications for them, and the spec that was issued by Muscatine Power and Water asked for those four applications. So, in a sense, that was common back then. But the chance part of it was the timing and the platform. At the time that I needed these, to find PTI had just finished writing them, and to find that they were writing them for the same platform that we were using was very lucky.

Daniel Molzahn (00:35:29):

I mean, there was a lot of platforms that could have been in place at the time. This wasn't like a standard platform people use; it's just one of many.

John McDonald (00:35:37):

Right, right. There were other computer manufacturers at the time—I think Gould out of Florida—that were being used for SCADA type applications. Yeah.

Julie Cohn (00:35:52):

Were there other consulting firms trying to get into this space also?

John McDonald (00:35:58):

Yeah, there were a lot of consulting firms: Weston, Weston Engineering, Systems Control, Systems Control. See, I lived in the Bay Area; Systems Control was kind of unusual in that part of the company were consultants, and the other part of the company built systems. They were a vendor. So, there were many utility customers—or let's say vendors. You're in a meeting with the consulting side of Systems Control, and they're asking all kinds of questions about the guts of your applications and how they work, thinking: what's to prevent you from going across the street? I think these buildings were across the street in the Bay Area. Telling the developers all the secrets about what we're doing. So, there were many times in that situation where—and it was unusual—I'd say, “I'd be happy to tell you the details of what we do, but I'd like to just maybe tell the customer, who's in the meeting, and not tell the consultant, so the customer can appreciate what we're doing, but I don't want to give our secrets away," so they—yeah.

(00:37:30): That was a very, very common one: Systems Control, Westin Engineering. And then later on, what happened was in the industry later on, the two premier consulting companies in the US for SCADA EMS, where there were two: ECC, Energy Control Consultants, who was based in Fairfax, Virginia, the CEO was Herman Amelink; and the other one was Macro Corporation, based in Fort Washington, Pennsylvania, a Philadelphia suburb, and Dick Berman was the fellow that would lead that group.

Julie Cohn (00:38:23):

Were there any universities active in this space in their research activities?

John McDonald (00:38:39):

Well, at Purdue beginning in '69 and through the '70s, was a very strong power engineering program that was developing a lot of power application software. So, the grad students were doing—and the professors like El-Abiad and Jerry Heydt on the power system side were very visionary. But I would say: to me, when I think about my master's thesis and the research, and the papers that I used to help with triangular factorization of a bus admittance matrix to Jacobian, what was interesting was, a lot of the development was coming out of Bonneville Power Administration. So, you think, wow, here's the utility who, their researchers are Bill Tinney from BPA. If you look at my master's thesis, there's papers from Bill Tinney from BPA that we used to help us invert a three-dimensional three-phase bus admittance matrix; triangular factorization with sparse matrices. So, it was amazing to—when I think back on it, and this wasn't just the early seventies, but Bonneville Power—to me—was revolutionary. I think of all the—Carson Taylor with voltage, his book on what voltage support, when he was about—there's been so much developments coming out of Bonneville Power, so many key people there; that's what comes to my mind. Going back to 1970, '71, '72, and continuing.

Julie Cohn (00:40:50):

Is that still true today, or has that changed?

John McDonald (00:40:53):

It's changed, yeah. Not so much, yeah; not so much.

Daniel Molzahn (00:41:01):

Do you have any intuition or insight as to why you think that trend change happened, or where are the Bill Tinneys and Carson Taylors working on?

(00:41:16): Yeah. I just think that in industry, what's happened is, in time, we've—industry has become much more transactional, short-term, and less strategic. In other words, how many sales can you bring me before the end of the quarter? And I really don't want to talk to you or think about anything beyond the quarter. We've become so transactional, so focused on that. Companies have a product, and you're going to invest. You, your development people, and your customers who said, We need these enhancements to the product. And so, you lay out a product development roadmap for the next two or three years with functionality that the customers need. And it's not unusual for companies to get into a squeeze.

(00:42:27): And they cut development. And so, the product—when it gets done—has half of the functionality that was originally planned. And the customer says, “Wait a minute, that's— It's done, but it's not providing me all the value that I expected.” So, I just—I see we don't value or fund longer-term: longer-term research and people that do that as much as we used to. We’ve become—I'd say—almost a microwave mentality. I didn't grow up with microwaves, so I grew up—if I wanted tea, I boiled water. If I wanted to make oatmeal for breakfast, I boiled water, put the oats in, cooked it. When my grandmother taught home economics to high school girls for 40 years—and in the 1950s, when my brother and I spent the night at grandma at grandpa's house, we spent all Saturday in the kitchen—she taught us how to bake.

(00:43:37): And everything was from scratch; there were no mixes. I cut lard into flour to make pie crust. That's the way I learned to bake. And so, things are so different today. I think instant gratification, having things done very quickly, making knee-jerk decisions—which aren't always the best decisions to make—seem to be the norm. We just expect things to be done too quickly, don't give things enough time. We don't spend enough time getting to know each other. You find a friend and you say, "Hey, I want you to do this. I'll see you later." Wait a minute, maybe the friend's busy. Why don't you find out what your friend's doing now? Show some interest in other people. Spend some time getting to know people before you ask them to do what you want them to do. We just don't—we're in too much of a rush.

Julie Cohn (00:44:39):

So, I don't wanna lose the thread of the story you're telling about the SCADA AGC and three other activities, <laugh> intervention you made in the industry. So, you got to the end of the 18-months—

John McDonald (00:44:55):

Well, what happened was I signed the license agreement for the company. I spent three weeks at PTI, going through every line of source code in the four programs, source code training, brought the programs back to Santa Clara, California, and worked with our software people to integrate those into our base platform. 'Because your base SCADA system, a SCADA AGC system, has two parts: the base platform does your generic supervisory control; and data acquisition collects the data and processes the data. But the applications that sit on top of that use that data—like to calculate area control error or economic dispatch—looking at specific things about the grid. Then they put the results back into the SCADA database, and then control commands go out to implement the decisions.

(00:45:54):

So, we had a lot of work to do to effectively integrate these high-powered applications into the basic—I was the only one at the company that knew the applications; there were no power engineers in the company, but they knew the basic SCADA platform. So, you can imagine we spent a lot of time in it with that integration and displays and control points and all the things. And we got— So we got everything working, factory-tested it, delivered it, and everything worked fine. And what was cool was that that's a big step for a SCADA company to go from generic SCADA; now all of a sudden you can supply SCADA AGC systems. And I say to a vendor, “The step from SCADA to SCADA AGC from technology isn't really that great.”

(00:46:53): But the impact and the benefits to the customer are huge, just economic dispatch can save a utility 0.2 to 1.2% in annual fuel costs in one year. So just take how much a utility spends in fuel in one year. Take 0.2% of that in one application—it can save you that—it's a tremendous amount of money. And you take AGC, economic dispatch, interchange scheduling, and interchange evaluation; these four have tremendous benefits, huge significant benefits, but from a cost point of view, it's not that great. So, that was a huge jump for this company, and opened up a marketplace to us we didn't have available before.

Julie Cohn (00:47:52):

So, the first implementation—you named the utility, but I can't remember.

John McDonald (00:47:55):

Muscatine Power and Water.

Julie Cohn (00:47:57)

Muscatine: where is that?

John McDonald (00:47:58):

Iowa.

Julie Cohn (00:47:59):

Oh, right. It worked the first time?

John McDonald (00:48:03):

Yeah.

Julie Cohn (00:48:04):

Wow. Really?

John McDonald (00:48:05):

Well, there were a lot of hiccups with the first time.

Julie Cohn (00:48:07):

Yeah.

John McDonald (00:48:10):

But a lot of it's fine-tuning things; the basic foundation was solid.

Julie Cohn (00:48:16):

And this was the first implementation of this in this field, period?

John McDonald (00:48:21):

Well, it was one of the first, because PTI was interesting; they weren't a SCADA company.

Julie Cohn (00:48:29):

Yeah.

John McDonald (00:48:30):

They were a software company, a consulting company. So, they were writing applications, but they were going to work with the utility Toledo Edison on implementing them. So, it was kind of unusual because I worked for a SCADA company, so we were skilled in integration, skilled in hardware and software, and bringing it all together. You could have a very good software vendor, but integration and delivering a system that works is much more complicated than just writing the software.

Julie Cohn (00:49:08):

Yeah.

John McDonald (00:49:08):

Especially something like AGC. It's not a--. Economic dispatch, interchange, they're more on demand programs. But AGC is running every two seconds.

Julie Cohn (00:49:23):

Yeah.

John McDonald (00:49:24):

It's real-time.

Julie Cohn (00:49:24):

Yeah.

John McDonald (00:49:25):

Adds a lot of complexity to it because it requires data coming in from the field at least every two seconds. All the generation data, all the tie line data, all the frequency data every four seconds, it's sending control signals out to the thermal plants for regulation of thermal units, and you have to fine-tune. I've spent—with many utilities—days in power plants tuning software to the individual characteristics of each thermal generating unit.

Julie Cohn (00:49:58):

Oh, okay.

John McDonald (00:49:59):

The time constant—when I sent a one hundred-millisecond pulse to this 10-story boiler, how many megawatts do I get out of it? A hundred-millisecond or 200-millisecond? And then the time constant, how long does it take to give me that? Because every four seconds—when I'm controlling units—I need to know if I send a pulse to this unit, what am I going to get out of it? How long is it going to take? 'Cause I have area controll error that I have to reduce to zero.

Julie Cohn (00:50:30):

Right.

John McDonald (00:50:31):

I've got the change; the difference, between actual system frequency, difference between actual scheduled interchange. I'm calculating every two seconds. Every four seconds I want to get that down to zero, but I can't. I can't send a pulse to the unit that has a time constant of two minutes to expect things to happen quickly. So, it's a hydro unit, coal—some units are extremely fast, some take forever; you really have to know that, and you have to build that into your algorithm. So, there's a tuning process of implementing the AGC software.

(00:51:14): And so, the other thing is you could tune it on an individual unit basis. And we had one utility—units were so fast—that they said, Good luck, John. When you put multiple units on control at the same time, I wouldn't be surprised if you have a—you get into instability quickly because they're going to buck each other; they're not going to be coordinated and stuff, and then you have to go through the tuning parameters and really fine-tune. And so, these coal-fired units were so fast that it took us some time not just to tune each one, but then to have multiple units on regulation, and have a stable regulating situation with multiple units.

Julie Cohn (00:52:07):

So, I kind of wanna go in two directions here with questions, but I'll stick with one for now, and maybe if we have time circle back to the second. So, after the Muscatine implementation, what was the trajectory of growth for this product that your company now had to offer to the utilities?

John McDonald (00:52:28):

So, a couple things: one was, it was an 18-month cycle, and so we were—I was at the company maybe two years at that point, a little over two years, and they never hired any more power engineers. <laugh> So, I think what happened was, I met the Brown Boveri fellow in charge. He really liked me and my background. And, we had our hands full with this million-dollar system. You didn't wanna bid a bunch of other ones <laugh> because we—let's get the first one done and make sure it works 'cause we had never done it before, so the growth in that time-period—we were so focused on that one system and getting it to work. Now, in my personal life at the time—during this time, it was on the airplane.

(00:53:33): Well, connecting flying from Schenectady—which is the Albany New York airport through Chicago to change planes to go to San Jose, where my car was at the airport—I flew in and outta San Jose, 'cause I'm living in Santa Clara. When I was negotiating a license agreement with PTI, I flew from—finished the negotiation meeting, flew from Albany to Chicago. My flight to San Jose was canceled by United. United said, "We can fly standby to San Francisco or Oakland, which one? And we'll pay for a taxi to take you to the San Jose airport to get your car." So, I said, "San Francisco." I got—I was on a standby list—the last seat on the airplane and sat next to my wife; that's how we met. So she was on the aisle, and there's a very pretty, young girl from Dallas, Texas, on the window.

(00:54:26): And so, I compete in a lot of professional eating contests. <laugh>

(00:54:33):

I'm used to—I can eat a tremendous amount of food and never get full, so they give us a meal on the airplane. I inhale my meal; it's gone. And I must have been staring at Jo-Ann's's on the aisle—her meal—and she said, "Would you like my roll?" I said, "Yeah." And I ate her roll. And then the girl, on my right, "Would you like my roll?" I said, "Yeah." I ate her roll. And then I was staring at Jo-Ann's's dessert, "Would you like my dessert?" I said, "Yeah." And that girl on my right, looks, says, "John, I really like this dessert. I'm gonna eat it." <laugh> So, I married the girl that gave me the most food. <laugh> So, then we met on the airplane in June.

(00:55:11): And it was during this process, of this work; Jo-Ann's and my first date was July. So, I flew back to Chicago for my ten-year high school reunion, took Jo-Ann, first date; then three weeks of source code training in Schenectady for three weeks. On the weekends, I met Jo-Ann. We went to Niagara Falls and Toronto, and that's when we got engaged. And then Labor Day weekend, I moved her from Chicago out to Santa Clara. So, you can see during this very busy time at work, my personal life's changing a lot. <laugh> And I went from a peak of bachelorhood to now being engaged. My wife— My fiancée's with me in my apartment in Santa Clara, planning a wedding. So, what happened was my focus was always with work, but it was much more important now: wedding, buying a townhouse, and having a baby.

(00:56:19): Our daughter was born in San Jose. At that point, the company could have grown tremendously, especially with—but that was when Jo-Ann and I said, We have a baby girl now, our priorities are different, where's the best place to raise a family? So, after three years, I left Brown Boveri Control Systems. So, the growth part of it, I don't know. We got the system done and installed, but I really wanted to move out of California and live in a place that was better for raising a family.

Julie Cohn (00:57:06):

So, did your focus on what you wanted to do professionally change also when you moved?

John McDonald (00:57:11):

Well, I wasn't—we wanted to move outta California and my whole working life at that point was in California. <laugh> So, you contact executive recruiters. And I was lucky that McGraw-Edison Power Systems at the time, in Pittsburgh, was the largest supplier of distribution equipment. Five hundred-million dollars a year, their power systems division, of just equipment, particularly for the distribution part of the grid. And they're based in Pittsburgh. And McGraw-Edison—the CEO of power systems division, Bobby Gunn, had a vision that we have all this equipment, but if we could supply automation systems that automate that equipment, there'd be pull through. We supply automation systems to the utility, and they could say, We need equipment to automate; and they come to us for the equipment. Very brilliant. And this was in 19- early '82, so there wasn't a lot of automation. There wasn't a lot of automation at the distribution level. It was a—my thesis—three-phase unbalanced load flow—was all about transmission. No one ever thought about distribution and still didn't for many, many years. So, this was revolutionary—

Daniel Molzahn (00:58:59):

So, can I ask you a question, <inaudible>? So, when you were working on your thesis, was there ever the idea that it might be applicable to distribution systems, or you really were focused on transmission system at that time?

John McDonald (00:59:11):

Focused on--, because no one thought about distribution. And so, the question is: what real data did we use in our thesis to test it? What was Consumer's Energy [*Consumers Power Company*] in Michigan? Had some real imbalance issues with their transmission system. And if you read our thesis and the actual real data that we use and who we acknowledge to help us, it was engineers at Consumers Power. It was all transmission.

Daniel Molzahn (00:59:41):

Interesting.

John McDonald (00:59:42):

Large single-phase loads, lines that had a lot of mutual coupling who created problems: single pole switching stuff.

Daniel Molzahn (00:59:50):

Was that coming elsewhere in the country as well, or—

John McDonald (00:59:55):

Yeah.

Daniel Molzahn (00:59:56):

Okay.

John McDonald (00:59:56):

But no one had really—people had experienced it initially but not done anything about it because we didn't have the analytical tools at the time. The first attempt at a three-phase load flow at Purdue was with David Tarsi, with El-Abiad was with symmetrical components. And that was a disaster because the modeling—when you'd look at imbalances and you're using symmetrical components; it doesn't—didn't—work. And so, El-Abiad learned with experience with David Tarsi that, he said, "The next thesis that I'm gonna assign, we're gonna do three-phase load flow Newton-Raphson math, but we're gonna use Cartesian coordinates, and then we can model and balance."

(01:00:51):

And problem was—at the time—there were no generator models for three-phase, there were no transformer models for three-phase, and we didn't know what the—we had never had a three-dimensional y-bus before; instead of one element, now you have a three-by-three sub-matrix. And then we introduced the concept of fictitious buses where if you have untransposed [transposed] lines and you want to include the characteristics before and after the transposition that are different, we introduced a fictitious bus in the y-bus, had the modeling in both sides. And then in the process of the calculation, we used Kron reduction of three-dimensional elements in a matrix, to reduce it down to only the buses we wanted in the final solution.

Daniel Molzahn (01:01:33):

Okay. Got it.

John McDonald (01:01:47):

We eliminated the fictitious buses. So, a lot of that was—it just hadn't been done.

Daniel Molzahn (01:01:53):

Was there—there was the mathematical techniques for it—like you had mentioned earlier—matrix factorization, sparse matrices, these sort of things that had been in place relatively recently before this work, so how much did you take inspiration from—I mean, you must have needed to use those techniques to make this.

John McDonald (01:02:10):

We did traditional—we used a lot of inspiration from Bill Tinney and Tinney's work, but the application of his work was all on a single-phase balanced system.

(01:02:21):

No one had ever applied it to a three-phase system with a—looking at the—all three phases where your y-bus is much more complex.

Daniel Molzahn (01:02:31):

And do you think this was—I mean, from what you were indicating there was real problems with phase imbalance that people presumably wanted to address, do you have a sense of why were you guys the first? Like, was there other people that had been looking at it and had been stuck at using special components, or was it—what was the—why you guys?

John McDonald (01:02:57):

That's a good question. Being a young college student at the time and just following the directions from my professor, El-Abiad—but I'm thinking that first book was published in 1968, <laugh> so we're really—I think at that point, the inspiration for the industry was: here's a book reference we can use. And I think a lot more focus then was: how to use a digital computer to model the power system, but on a single-phase basis. So, I really think—now El-Abiad talks to me in, what, 1970, so we're only a couple years into the book being out—that the focus at that point was on: how do we apply the book to the single-phase balanced problem, whether it's z-bus, y-bus, or all the different flowcharts that were in the book?

John McDonald (01:03:55):

And we had our hands full; people had their hands full doing that. And all of a sudden El-Abiad said, “No, I wanna go beyond that. I wanna look at three-phases."

Daniel Molzahn:

Sure.

John McDonald:

And I think most people are saying, Let's get single-phase.

Daniel Molzahn (01:04:12):

So, he's quite a visionary then, it sounds like.

John McDonald (01:04:13)):

So, he kept pushing things. And I'll never forget one of—our graduate class, using his book, he looks at us, he says, “In one week I want you to write three load flow programs from scratch,” for this IEEE 15-bus system or something, “I want you to write from scratch, Gauss-Seidel, Newton-Raphson, and fast decoupled. And we said, We're taking other courses, and we're working on research. And he just couldn't understand that because he could do it himself, and he expected us to be able to do it.

(01:04:59): And we’re going, “this is crazy, man.” <laugh> My whole life was gonna be—and remember now when I wrote a program, I used fan-fold paper that I took from the computer center. Remember now. And I took it to my fraternity house room and I spread it out on the floor of my room with a pencil. And I start at the top with dimension statements—whatever—and I start writing line by line—the code—in pencil. And when I needed a subroutine, I'd go down further and— [*gestures as if writing*] --a subroutine and go back up. And I'm writing this by hand. I take that paper, put my boots on, my winter coat, my hat—the winter in Chicago [*at Purdue*]—walk to the computer center, wait in line for a keypunch machine. I keypunch hundreds of cards, put 'em through a card reader, and check to fix all the typos, then take the deck and turn it into the computer center. It could take an hour to get my results. It could take six hours. It could take 10 hours. You don't know.

Julie Cohn (01:06:07):

And if there was an error?

John McDonald (01:06:09):

There always was. <laugh>

Julie Cohn (01:06:10):

You wouldn't know till the end of that?

John McDonald (01:06:11):

There always was. You get it back and say, “Oh, I need—I didn't catch that. Oh, now I lost time. Now I gotta fix it and turn it in again and wait again. So, it took—to do these programs, I mean—forever.

Julie Cohn (01:06:27):

Well, that leads me to the second line of questioning I had in mind, which was: at the time you were—I don't mean to overly dwell on the SCADA AGC, but it's just an interesting historical point. There had to have been advances on the hardware side of the computing industry in order for the computers to manage this quantity of data and analysis quickly enough to be useful.

John McDonald (01:06:54):

Right.

Julie Cohn (01:06:55):

Was that a parallel process that was happening that made it possible for you all to accomplish what you were trying to do?

John McDonald (01:07:03):

So, there was an intermediate step which, because of the need to have a more effective operating system for real-time multitasking applications, before we had computer platform operating systems that were meant for real-time. Remember now, for many years, these multimillion-dollar energy management systems were custom-made, so they were always late, always way over budget, and had dedicated hardware and software teams. The philosophy of the customer at the time was: if I'm gonna spend that much money, I want exactly what I dictate. And the vendors—that was the norm, and it was horrendous. So, what the vendors were doing was taking computer platforms—like the Gould computers—and modifying the computer manufacturer's operating system to give it more real-time capability.

Julie Cohn (01:08:08):

Oh.

John McDonald (01:08:10):

We think of: you want a standard system, but not only was the SCADA code from the vendor custom written; now you modified the operating system from the computer vendor. Talk about a one off.

Julie Cohn (01:08:26):

So, they bought the GMC 15-passenger van, changed the engine, and then remodeled the interior, <laugh> to do something else?

John McDonald (01:08:38):

Right. (speaking at same time) And now a couple years later, you go back to the vendor and say, “Well, I have three more kids or something; I wanna upgrade this thing.” Well, all the people that built your car initially had all left the company.

Julie Cohn (01:08:51):

Yeah.

John McDonald (01:08:52):

Okay.

Julie Cohn (01:08:53):

Yeah.

John McDonald (01:08:54):

No, seriously.

Julie Cohn:

Yeah.

John McDonald:

Upgrading these custom systems was impossible 'cause they were all unique.

Julie Cohn (01:09:01):

So, the fact that HP produced Hewlett Packard-produced computers—that could be a platform for the FORTRAN programs—was an innovation on the computing side that mattered a lot.

John McDonald (01:09:17):

Right. So, I was in Pittsburgh four years with McGraw Edison Power Systems. And the team I put together built some of the first distribution automation and load management systems. So, we automated the distribution part of the grid, which was kind of unique at the time.

(01:09:38):

You saw load management systems, but you really didn't see distribution automation systems. And I did that for four years. And then Cooper Industries bought McGraw Edison Power Systems.

Julie Cohn (01:09:53):

Oh.

John McDonald (01:09:54):

And that's when Cooper Power formed.

(01:09:57): And when I was at McGraw Edison in Pittsburgh I said, “I'm building these systems.” It'd be strategic if we could team with a well-known SCADA vendor in distribution because I was just my team. We were just getting into it. And I had a good team of programmers, but a lot of them weren't strong in power system background; that came from me, and distribution was very new at the time. So, I made trips to Advanced Control Systems here in Atlanta, in Norcross. ACS was one of the well-known distribution SCADA vendors at the time. They started in 1975. And so, I was coming to see them in '82 to '86. And the founder of the company, John Muench, and founder with Peter Wu, and Ken Murphy—those three founded the company.

(01:11:04):

Meeting with 'em, trying to put a joint venture together, and meeting with Tejas Controls in Houston was—so, all the distribution SCADA bids all came down to one of two; either one of two companies would win. Tejas Controls in Houston, or Advanced Control Systems here in Atlanta. And so, I knew the leadership of both companies. But when Cooper bought McGraw, it’s too bad, because we really loved Pittsburgh. Our son was born in Pittsburgh. We loved the suburb we lived in. But they asked me to move to Wisconsin—which would've been okay—but I'm thinking if I have to move, I wanna make sure I'm moving for the best opportunity for me, not just to follow this company. And that's when—this was in the days of, your resume, you'd send your resume out to recruiters and the recruiter physically took a small bottle of white-out, a small bottle of white-out. So, it had a little paintbrush in it and a white liquid.

(01:12:15): And they take the little paintbrush out and my hard copy resume, and they put this thick white paint over my name and my company. It was called a blind resume. And so, they did that to my resume; many recruiters did and sent it out to lots of people. So, the founder of Advanced Control

Systems here in Atlanta—who knew me from the meetings I had with him to put this joint venture together —calls me in Pittsburgh, says, “John, I think I have your resume,” <laugh> “Why didn't you tell me you're looking for a job?” <laugh> And I said, “Well, my wife and I are from the Midwest, have two young kids.” They were one and four. We were just looking at the Midwest and we'd never thought about living in the South.

(01:13:04): And he's, “John, you know the company. I'll create a position reporting to me; you know the leadership of the company. You and your wife come down for four days, all for free on me.” And I said, “Well, let me go home and talk to my wife tonight.” He says, “John, it's a free trip. How can you not say yes?” I said, “I'm not gonna go unless we would move to the South.” We hadn't even thought about living in Atlanta or anywhere south, so we talked about it that night. And I've always—in my life—said, “Don't discount something unless you try it ‘cause it could be a lot better than what you anticipate." So, we leave Pittsburgh, and it was November, snowing, <laugh> land in Atlanta. It's sunny, it's warm. <laugh> My wife is a residential interior designer.

(01:13:55): She fell in love with the architecture here—*Gone With the Wind*, the plantation homes with the big white columns—and I knew I liked the company because I had SCADA experience, and they loved my background. So, in 1986, I joined ACS and all of a sudden, I see we're using HP RTE, Real-Time Executive as the operating system. And it's the first operating system I'd ever seen that was truly designed for real-time operation. Very efficient. And we were using that as our platform for all of our SCADA systems. Now what's interesting is: that company had only done generic SCADA; they had never done SCADA AGC.

Julie Cohn (01:14:43):

Oh.

John McDonald (01:14:45):

So, a fellow—very, very good programmer—and I worked hand in hand. Basically, I didn't write all the code, but I designed the code AGC. He programmed it with me, and we took that company from a SCADA company to a SCADA AGC company. <interruption>

John McDonald (01:15:33):

What was interesting was one of the projects that we won was Muscatine Power and Water.

Julie Cohn (01:15:37)

Oh, how funny.

John McDonald (01:15:41):

So, what they had done was outgrown the system I did for them.

Julie Cohn (01:15:46):

Yeah.

John McDonald (01:15:48):

In 1980—1979 and '80. And now this was around '89 '90. And they're looking for a new system. And Macro Corporation was a consultant. So, I worked with the consultant, and of course, the customer knew me. And there were three bidders, and it was over a $1,000,000 system, again. And we won. So that was Advanced Control Systems' first—that was their first SCADA AGC system. I was able to work with the same utility twice.

Julie Cohn (01:16:29):

Did you have other questions about the three-phase load flow model? I think I sort of cut you off.

Daniel Molzahn (01:16:35):

No, no. I did have one other question for you. So, you said you used Cartesian coordinates for the phase coordinates with Cartesian representation of voltages. Is that right?

John McDonald:

Yeah.

Daniel Molzahn:

Why that versus polar? You could have used voltage made into its angles instead of Cartesian coordinates; did you try both? And—

John McDonald (01:16:54):

Actually we—there is some polar—I have to get into the paper again—details—but there is some combination of polar that we employed.

Daniel Molzahn (01:17:08:

Oh, you did? Okay.

John McDonald (01:17:08):

Yeah, yeah. So, we did; we did.

Daniel Molzahn (01:17:12):

Yeah. How much of experimentation did you do with this—and I imagine your reams of paper converted to punch cards didn't allow for fast iterations on different variants—so, was it you found something that worked, or you sort of exhaustively tried everything, or—

John McDonald (01:17:31):

What we did was initially our—we split the task into three steps 'cause there were three of us all trying to get our master's degrees. And the CDC 7600 computer system for the whole Purdue campus was dual 6600s—huge main mainframes—and there wasn't enough memory to load our entire program and to run it. So, the computer center told us it was two-and-a-half boxes of punch computer cards; one program. And so, they said we could only run it overnight. We said, No, we can't, we need more runs to grad—we won't graduate. So, we implemented something called overlays. Back then, if you didn't have enough memory, so, we had to—so, not only the power system part of it but just getting by the computational limitations at the time.

John McDonald (01:18:30):

We had a series of main overlays and secondary overlays. The main overlay was there the whole time—kind of like the brains—but, like, the first overlay would come in. It would—that code would be loaded. It would do its work. And we put the results in a certain place, and then that code would be overwritten by the next overlay, who would use the results. And then another overlay, another overlay. So, we had the structuring of our program—

Daniel Molzahn (01:19:05):

It was almost a distributed computation?

John McDonald (01:19:06):

Yeah.

Daniel Molzahn (01:19:08):

In a different setting than we think of today—

John McDonald (01:19:10):

And then we had to convince the computer center to give us more runs per day. So, we were struggling with—we were really—we were meeting with El-Abiad once a week, and because we were doing things that no one had ever done before, there weren't papers that we could read on three-phase models of transformers.

(01:19:35):

There were no papers that said, Well, if you model it this way, it's going to adversely affect the convergence characteristics of the Newton-Raphson mathematics. We had to learn that ourselves.

Daniel Molzahn (01:19:47):

And did you learn that by just experimenting, or did you have some intuition about condition numbers of matrices?

John McDonald (01:19:53):

We relied on El-Abiad.

Daniel Molzahn (01:19:55):

Okay.

John McDonald (01:19:56):

We had to rely on his vision, because we were reading as much as we could that was available, but we were plowing new ground in many respects. And El-Abiad— Jerry Heydt was the professor at Purdue that I would go to with homework problems and things—nicest guy in the world. And very sharp and very accessible. El-Abiad was so heads above everyone with his intellectual capacity. And he just—when you talk to him, he'd say something and you'd say, “Wait a minute, what was that again?” 'Cause you're— <laugh> It's way up here, and you say, “I gotta implement this somehow, but let me think about this.” And you, it'd be iterations with him. And so, our weekly meetings with him about our thesis was just trying to—what is he saying? What does he want us to do? Try and interpret it 'cause he's way up here; we're down here.

Julie Cohn (01:21:00):

Go ahead.

Daniel Molzahn (01:21:01):

So how much did you look at other computational work that was going on at the time outside of the power systems, right? People all were using computers, trying? I imagine it—I wasn't there. I imagine they're trying to use computers for lots of different applications. Were you paying attention to that work, or were you really focused on power industries?

John McDonald (01:21:20):

That's a good question. I think part of it was since there was no internet, it was so hard to get information, and there weren't that many industry meetings at the time like there are today. Plus, we had such an ambitious schedule of coursework and thesis and all that. I mean, I could only think that we were just so zoned in on what we were trying to accomplish.

(01:21:49):

And it was all we could do to get that done. And we got everything to work really well very close to graduation. So, our actual IEEE transactions paper was published in '75. We graduated in '74, and we presented it in 1975 at the summer meeting, which happened to be in San Francisco. And Ken Birt—one of the three guys—his wife was getting her PhD at Purdue, so he was gonna stay on campus for another year. And we worked with him, but he was the leader, putting all of our final results together, and finishing a final thesis document, which was finished in '75 'cause it was all we could do to get things to work. <laugh>

Julie Cohn (01:22:41):

So, it was part of IEEE transactions in '76?

John McDonald (01:22:45):

'75.

Julie Cohn (01:22:46):

'75. Yeah. And yeah. <inaudible> And I guess, how quickly did people outside of the academic world pay attention and feel that this was something important to practice?

John McDonald (01:23:03):

Yeah. So, I think we had a lot of questions when we presented the paper.

Julie Cohn (01:23:08):

That's always a good sign. <laugh>

John McDonald (01:23:10):

Which is a good sign. There were a lot of interest in it because I think one was El-Abiad was involved, 'cause people knew it was visionary. The second that we got it to work in a way that had not been done before. And so—like we said—people had imbalance issues, but they weren't attacking them at the time and didn't know how to. And this kind of gave them some confidence that it could be done. So, this was 1975, but we still stayed on the transmission level for quite a while. It wasn't until 1988. So, think about that: 1988. I started Advanced Control Systems in '86—and remember it was just the basic SCADA company—but for the distribution part of the grid: no special applications.

(01:24:08):

'86, '87, '88, February of '88, the very first SCADA EMS Generation Transmission Company, well known at the time, ESCA. ESCA was founded by 12 very, very smart people from the Bay Area—I think they were with Systems Control that we talked about—and they said, We're gonna start an EMS company. Their expertise was in generation transmission SCADA EMS. And they went to Seattle, formed ESCA in Seattle. And they started with dispatcher training simulators, and they went into full-blown EMS systems. Tremendous company. The 12 brilliant people that founded this company. And what was interesting was the leadership of the company—not the technical—but the president and vice president had a vision that said, in '88, If we can do this on generation transmission, can we do it on distribution? 1988.

(01:25:19): That was unheard of. No one was thinking about that at the time. We were doing plain vanilla SCADA—like ACS, like Tejas in Houston—but not with sophisticated applications like an EMS with contingency analysis, state estimator, topology processing, load flow, stuff like that.

(01:25:44): This was visionary, so they contact me. They said, Who in the United States knows distribution and could lead this effort for us? And so, they contacted me in Atlanta here, flew my wife and I to Seattle for four days in February of '88. And courted me to say, We want you to take us into

DMS, distribution management systems, for the first time, 'cause we really have a vision that the stuff we're doing—. It's standard today, but back then it was unique; it was revolutionary.

(01:26:27): So, the best thing for me was—and this is why it's so important to build out your network and keep in contact with people—the 12 founders. I had lived in the Bay Area; had been to industry meetings; IEEE meetings, presenting papers. I presented every month at the IEEE-PES San Francisco chapter, Santa Clara Valley chapter, so a lot of these 12 I knew, and they knew me. So, interview process, I'm one-on-one with many of these founders, and I knew them. And I'd say, “Your expertise has always been in generation, transmission. Distribution is so different,” “An EMS assumes a single-phase system. Your database is very easy. You're just going out to substations; they're big substations, but you have a lot less substations. And everything's single phase, your models are single phase.

(01:27:36): You're just pulling in one voltage from the three phases, one current from the three phases, and assuming they're all the same. Distribution: you've got exponentially bigger databases 'cause you're not only going to substations, you've got many, many more substations. But you gotta go out on the feeders now.

(01:27:43): You've got switches, cap banks. Your models are all three-phase. You gotta have three-phase current and voltage; real and reactive power. DMS is a nightmare compared to EMS.” And I looked at each of these guys, “You really want do that?” And they said, Absolutely not; we don't wanna do this." And I said, “But these two guys that run the company—that flew me out here—really want to do it.” “Well, that's maybe what they want to do, but we are not interested in it.” I'm thinking, this is very insightful because if I hadn't known this, I could have easily accepted that offer, been tasked with a huge responsibility, and had no technical support in the company. None. Because it was ahead of its time, ahead of its time. Thank God. I mean it. February. You don't want to interview a company in Seattle in February.

Julie Cohn (01:28:58):

<laugh> Yeah.

John McDonald (01:28:59):

It rained for four days. It was horrible. Then you come back to Atlanta, it's sunny and warm.

(01:29:05): That made it easy. So, my wife said, “There's no way I am living here.” And I—they gave me a huge offer, but it was an easy decision because—even though I believed in it, I thought eventually the industry would go that way, and it would be fun for me to take a leading company like ESCA and be the one to do it—I had no support. So that was when I said, ”I wonder how much time it's gonna take for the industry to really embrace getting into DMS,” because there were people after me when I turned the offer down. There were people after friends of mine that were recruited, and one guy unfortunately accepted the offer 'cause he didn't have the insight I had, and it was disastrous. It wasn't successful.

(01:30:03): Ahead of its time, no support, so it took a number of years for the industry to embrace. Problem with distribution is when you're with an EMS, you can communicate with the substations with point-to-point communications like fiber optics or something. But when you get into distribution, you can communicate with the substations, with wired communications. But typically, there's so many, and many of 'em are more rural. You really need licensed, or unlicensed wireless UHF, because what we use as UHF communications. And there, with the DMS, you need point to multipoint, which is much more complicated. And the reliability of point-to-multipoint wireless communications to blanket a big area 'cause the feeders are going everywhere.

John McDonald (01:30:57):

And you've got stuff on those feeders out in Timbuktu, and you've gotta reach those with communications reliably. The business case for distribution automation was always there for a long time, but the stumbling block was the cost and reliability of the communications for a long time, and we had to get over that hurdle first before it was cost-effective.

Julie Cohn (01:31:27):

So, is it now standard for distribution companies to use this?

John McDonald (01:31:33):

Well, there was another driver here, and it was—'cause before I joined GE, I did 12 years of international consulting with KEMA, so I was the one writing the specs for SCADA systems and EMS and helping the utility. And so, it was very common that I'd be in the control center with a supervisor at the utility and I'd say, “I'm helping you with a new EMS. When do you think you'll get your first DMS?” And they'd laugh,

(01:32:06): “My distribution system is radial. Electricity's flowing in one direction: source to load. Why would I spend money on a DMS distribution SCADA? I don't need it.” And they'd laugh. And so, what happened was then, all of a sudden, the trend towards distributed generation. And the field worker used to go out in the field, a distribution, and say, “All I need to do is open the upstream device, and I have a safe de-energized work situation.”

Julie Cohn (01:32:38):

Yeah.

John McDonald (01:32:39):

And now you're coupling PV panels. You’re coupling all kinds of distributed generation all along distribution. You have electricity flowing in two directions, which is really messing us up with our protection readings, 'cause when I would set protective relays on distribution and do my short circuit study, I'd only look at the source side component for the fault. And if I have a lot of PV panels down there and the fault occurs when the sun's shining, I could have a significant load contribution to a fault that I didn't model. But the other thing is it's a varying load side contribution based on the intermittency. So, the distribution system is much more complex today. So now these same supervisors are saying, We have no choice, we have to get a DMS to manage the increase in complexity and to optimize our distribution system, it's just, we have no choice, you have to do it. So that's been the driver, is much more complexity with distribution than we've ever had before.

Julie Cohn (01:33:46):

We're getting close to an hour-and-a-half, so I think I'm gonna first ask Rachel if you have any questions you'd like to ask.

Rachel Harris (01:33:58):

One thing I had wondered—this is all the way back when you were talking about your first developing the SCADA AGC, a software platform you were providing for a utility company to use: was there hardware equipment they would need to install, like in the field, to make that possible, or was that already there?

John McDonald (01:34:16):

No, there—it's a good question because the control of a generator is—there's a—it is a governor that's in the power plant at the generator—like a fly-ball governor is what they used to call it—and it would be locally controlled, with control circuit at the generator, like through droop control. So, it'd be looking at frequency—but it'd be all local.

Rachel Harris (01:34:49):

Okay.

John McDonald (01:34:49):

Locally done with the governor. So, what we had to make sure when we installed AGC was the governor motor at the generator could accept an external command to override the local because now we're controlling the generators. If they're on regulation, we're controlling them from a SCADA master station in the AGC software, so that was one thing. And a lot of them—this was in 1984—we saw the first microprocessor-based relay.

Rachel Harris (01:35:24):

Okay.

John McDonald (01:35:25):

So, think about—I'm getting into AGC here at Advanced Control Systems in the late eighties, early nineties; now moving from mechanical governor controllers to more microprocessor-based, so everything was shifting to microprocessor-based. So, it was a good opportunity while the utility was adding AGC, it was a good opportunity for the power plant folks to look at their governors.

(01:35:53):

Say, these are old mechanical controllers we've been using for a long time, let's upgrade those to newer, maybe microprocessor based that give us the capability for external control, but also give us more functionality, that we could take advantage of with the AGC system.

Rachel Harris (01:36:10):

Okay. So, they were upgrading the control at the generator as well as adding this software at like the master center?

(01:36:18): Right. 'Cause we had to have the capability to send a—for the governor to accept an external control signal to override the local stuff.

Rachel Harris (01:36:30):

That makes sense. Thank you.

John McDonald (01:36:33):

At Georgia Tech, we talk about this, but I always say, “Don't be enamored with the microprocessor-based relay or the monitoring diagnostic device for the transformer. Think of—that has two-way communications, and they could be a node and a bigger network. So, if you wanna do the best you can for a customer, you take these technology components and integrate those together into a holistic solution.” The solution? A set of technology components from different vendors integrated together to successfully interoperate, so they have to comply with the same standards, meet the business needs of the customer. So, it's not the capacitor bank, but it's integrated volt/var control.

(01:37:23): It's not the switch on a feeder, but it's fault protection, isolation, restoration, logic. It's not the governor motor, but it's automatic generation control. You know what I mean? So, it's—you can provide more benefits to a customer if you think more of the big picture. And I always teach students and young professionals: always think of the big picture. And in a PowerPoint presentation—we did this, Dan, for your class—I show examples of six holistic solutions that we implement. And then at a high level, I show a detailed technology roadmap, color coded, of all the components with each of those six, and how they lay out, whether they're in a control center, the substation, the feeders, at a customer's house. And you can see they're spread out everywhere, but they all have two-way communications. Always think of the big picture.

Julie Cohn (01:38:21):

Do you have any more questions you wanted to—

Daniel Molzahn (01:38:23):

I don't think so. I appreciate the opportunity to ask you questions throughout. Yeah.

John McDonald:

Sure.

Julie Cohn (01:38:27):

Were there any questions you wish we had asked? <laugh>

John McDonald (01:38:30):

No. I think what happens is you realize—I've been working 48 years for six companies and IEEE, 52 years—how much you've been able to do.

Julie Cohn (01:38:41):

Yeah.

John McDonald (01:38:42):

And how much you forgot that you did. <laugh>

Julie Cohn (01:38:45):

Maybe we helped you resurrect some good memories.

John McDonald (01:38:47):

You did. <laugh>

(01:38:50): It's a learning experience. I think some takeaways would be: always challenge yourself, never, never take the comfortable route. But always take a more challenging route. Leave of absence from work for three months to go to Europe; petition Berkeley to withdraw from the MBA program for a quarter; and for Bechtel, fly to Northern Alberta near the Yukon, live in a trailer 30 miles from the nearest town: outdoors 10 hours a day, 50-below weather, managing 10 electricians on a construction site—I did that for three months, it was a lifestyle that I'll never repeat again. <laugh> But always, always look for things that really challenge you. Like getting off a plane in Hanoi, North Vietnam to work for two weeks. Getting off a plane in Yerevan, Armenia after they'd gotten their independence from Russia and had three hours of electricity per day and one hour of hot water every other day to shower. Those are the memorable trips. And always try to do as many of those things as you can, because you become more resourceful and more resilient. Nothing, you can't—you can conquer anything. You truly are confident that you can—there's nothing that you can't conquer.

Daniel Molzahn (01:40:30):

<laugh> Actually, I did think of one other question.

John McDonald (01:40:33):

Yeah.

Daniel Molzahn (01:40:33):

So, when you're working back on these load flow analyses and software decades ago, did you foresee the— Now we run how many hundreds of millions of power flows at a time, did you foresee that as a possibility, or is that something that you would've imagined at the time?

John McDonald (01:40:56):

The more familiar I got with the load flow application, I truly—'cause I'm—the reason I didn't get a PhD and I told El-Abiad, “I'm much more practical.” I said, “I want to get an MBA and I want to apply all the theory in the real world. I love explaining complicated things in an easy-to-understand way. I love to teach.” And so, to me, the load flow, and the reason why I really liked it was: I saw this type of simulation was so practical. I mean, to be able to say, “What if I switch a cap bank, or what if I trip this line, or what if I change the tap on a transformer? Am I gonna have any voltage limit problems or real/reactive power flow problems without actually doing it?”

(01:41:50):

I mean, without a—simulated is phenomenal, and if I'm an operator in a control center, I would want a load flow I could use in real time, snapshot the real-time conditions right now, and simulate something.

(01:42:04): And also, load flow I could use on demand with saved cases, because it's that valuable. So, I think—more so than my colleagues—I had a much more practical bent; always have.

(01:42:18):

And I really saw it—to me the load flow—and the other thing was I feel I really give a lot of—I really—I’m so fortunate to be hooked up with El-Abiad, because who would've thought in those days to try to do a three-phase load flow? We were just getting used to a single phase with his book and the limitations of the digital computer at the time, and how much we could model, compute, and analyze. But he didn't care; he just—it was a challenge for students. <laugh> But I was really fortunate to have him as a major professor, have an ambitious curriculum, an ambitious thesis, and all that stuff; really fortunate.

Julie Cohn (01:43:21):

Paid off for all of us. <laugh>

John McDonald (01:43:23):

Yeah.

Julie Cohn (01:43:25):

John, thank you very much for your time. We really appreciate it.

John McDonald (01:43:28):

Thank you. This was a lot of fun. Yeah. Thank you.

[End of Interview]