

**Algorithms & Power Systems Architecture:
Using Historical Analysis to Envision a Sustainable Future
Oral History Project**

Interviewee: Vijay Vittal

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Interviewer: Julie Cohn, Sairaj Dhople, Manish Singh

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Abstract:

Vijay Vittal, Regents Professor at Arizona State University, discusses his education – culminating in a Ph.D. from Iowa State University – and his long academic and research career. He describes his extensive work on stability and efforts to find a solution to determining the unstable equilibrium point (UEP) on power systems. He discusses the graduate work of Hsiao-Dong Chiang, and other mentors and students with whom he collaborated. He describes research support from the Electric Power Research Institute (EPRI), industry support from Siemens Empros, and application of his approach to UEP at Northern States Power and Ontario Hydro. Dr. Vittal discusses the work of various technical committees of the Institute for Electrical and Electronic Engineers (IEEE), and later urges those entering the field to be active in those technical committees. He reflects on three different ways stability is characterized and how that evolved over time. He discusses relying on techniques from other fields to actually solve for UEP as opposed to approximating it. Today vendors offer online tools that use this same approach. Dr. Vittal speculates that new models, new types of simulation may be needed to address

stability with high levels of inverter-based resources. He talks briefly about dispatchable generation – including nuclear and natural gas – as necessary components of future power systems. He closes with reflections on individuals who influenced his work, recommendations for young people entering the field, and a final comment on the implementation of UEP on the Ontario Hydro system.

Note regarding Transcript and Timestamps:

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

Transcript:

Julie Cohn ([00:01](#)):

This is Julie Cohn. I'm conducting an interview with Vijay Vittal on July 14th, 2023, at the Marriott Hotel in Orlando Florida. Sairaj Dhople and Manish Singh will assist with the interview. And during today's interview, we are especially interested in your early work on stability analysis and security assessment, and how it later was carried forward into industry's adoption of analytical solutions. But we'll begin with some introductory questions and general background information about you. So, if you will, please describe your educational background and your professional positions in the field of electrical engineering.

Vijay Vittal ([00:44](#)):

So, I started my bachelor's degree in India. It was a five-year degree from Bangalore University. And after finishing my bachelor's in electrical engineering I went to the Indian Institute of Technology, Kanpur, got my master's, and that's where I got interested in the field of stability. I had an advisor who worked in that particular area, worked on a project which dealt with stability; and then read a paper, a survey paper by one Aziz Fouad, on Lyapunov stability, applied to power systems, and then applied to Iowa State. And he had an EPRI project on the very same topic. And he admitted me and I became a student, and I did my PhD under him. It continued to be a long-lasting project. It went on for several years. And as a faculty member, I

continued to work on that. And the final stage of the project was an actual implementation at the utility. And I was a PI on that project by—right by that time my advisor had retired. So, I worked with Siemens Empros. They were the EMS system [*vendors*] and we implemented the project at Northern States Power, which is now Xcel Energy, part of Xcel Energy in Minnesota. So that's—some historical brief on how I started working in this area.

Julie Cohn ([02:29](#)):

And where are you located now?

Vijay Vittal ([02:31](#)):

I'm at Arizona State University. I moved there in January 2005, and I've been there ever since.

Julie Cohn ([02:40](#)):

And are you primarily a teaching professor? A research professor? Do you do work in the—?

Vijay Vittal ([02:46](#)):

I do both. I do—I teach a course every semester. I've taught a course every semester I've been in this field. And I do research.

Julie Cohn ([02:58](#)):

We're going to turn to questions related to your significant contributions to stability analysis and start with a challenge. What was the most important technical problem you tackled over the course of your career?

Vijay Vittal ([03:15](#)):

So, this Lyapunov function or energy function method is very appealing and sophisticated because it gives a direct solution to stability but looks very easy to apply for a simple system. But when it comes to application into a large realistic system, there are several issues: numerical issues, issues of ill conditioning. And in applying this method there is a need to find the domain of attraction, which is actually characterized by critical energy at something known as an unstable equilibrium point. So, in order to do that, you have to determine this unstable equilibrium point. That's very difficult to do in large realistic systems. Numerically, it's a very challenging problem. So, finding that out was—and making sure—because the entire solution depends on determining the right unstable equilibrium point, calculating the energy at it, and using that as a measure for the region of which bounds your stability. So those—that was—took a long time to actually come up with a very good solution for it.

Sairaj Dhople ([04:48](#)):

So, Professor Vittal, you talked a lot about controlled theoretic concepts. So, I'm just wondering if you go back, did you start out as a controls engineer that got interested in power, going back to your IIT days, or was it the other way?

Vijay Vittal ([05:02](#)):

So, the year I started off at IIT was when Vidyasagar came out with his book. This was a book on non-linear systems in academic press. So, Dr. Pai at IIT Kanpur taught out of that book. That's where I built this concept. But then I came to Iowa State and Anthony Michel was there, so I took a lot of courses from him. So that's how I built my background in that particular area, Anthony Miller and—Anthony Michel and Dick Miller. So, they had written this classic book on dynamical systems. So that's how I picked up that material.

Sairaj Dhople ([05:42](#)):

And was power engineering back at that time attracting the same level of attention, let's say, even like, across different social spheres as does is today? Or were there pressing problems that people were all excited about?

Vijay Vittal ([05:57](#)):

There were—at that time in the early '70s, there were—the transmission system was expanding in the US, so there was this idea of how you would do generation expansion. That was the big topic at that time, because load was growing at a pretty fast rate and people were adding generation. So how to systematically add generations. So EPRI came up with this tool called EGEAS, and that was the hot topic in those days. But then stability, always—security and stability were always a hot topic, but then NERC characterized reliability, security in very definite terms, and put up criteria which made sure that systems adhere to these criteria. And that's when—I think this has remained a hot topic ever since.

Sairaj Dhople ([07:01](#)):

So, it would be fair to say, then, that it was the growth in load and then the challenge of having and deploying generation that had stability certificates that ultimately prompted some of the investigations that you're talking about.

Julie Cohn ([07:16](#)):

I want to circle back to something that, as a non-engineer, I find intriguing: the idea of unstable equilibrium, because—would you take a moment just to explain that for the non-engineer who might be interested?

Vijay Vittal ([07:33](#)):

So, if you have a system—a stable equilibrium point will always draw the trajectory of the system towards it. An unstable equilibrium point, depending upon the nature of the unstable

equilibrium point, could have regions around it where—if you land, you'll move away from the equilibrium point. It does not attract the trajectory of your dynamical system towards it. So, in that sense, that's how you—and the trajectories begin to grow. And you essentially diverge away from that equilibrium point, so that's how it is characterized.

Julie Cohn ([08:19](#)):

Interesting. So how did you begin to tackle the challenge that you were thinking about?

Vijay Vittal ([08:30](#)):

So, there were many ways—things we had to identify how to tackle this problem. We realized very soon that at one time people thought that the unstable equilibrium point, which had the lowest energy was the one which was, which decided the region of attraction. But then we found out that was not very true because that gave very conservative results. It really did not match. The tool for comparing the result, which this direct method gave, was what is known as time domain simulation. You actually integrate the differential equations, put the disturbance and see what happens. So, it gave results which are far too conservative to actually apply in practice. But while doing this time-to-mean simulation, we observed that the angular positions that we saw of the rotating machines at those instances were quite far away from the angles described by this lowest energy equilibrium point.

([09:53](#)):

So, we then surmised that this probably had to deal with where the disturbance took you, and there probably was an unstable equilibrium point closer to that trajectory than the trajectory characterized by this lowest energy unstable equilibrium point. So—characterize that as a controlling unstable equilibrium point. And that's how we hit upon it. And then came up with methods to actually determine how you would go towards that and calculate the energy towards that. And at that time there was some work from Berkeley. There was another investigator in this area called Hsiao-Dong Chiang, and he came up with this method of

determining where the trajectory left this thing known as a potential energy boundary surface. And he used that and came up with this idea of actually determining the correct unstability of the equilibrium point.

Manish Singh ([11:00](#)):

So, you pointed at a very interesting observation, and that reminds me that these days when we want to validate anything in graduate school or in undergrad, we can do time domain simulations pretty fast, even though we call it restrictive. But back in the day, the computational resources were so less. So how were you able to do these time domain simulations, and how did you set it up so that you can get enough insight by limited number of tests by that time?

Vijay Vittal ([11:21](#)):

By the time when we were working on this, we had—the VAX systems were there, we had enough capability, we had commercial software. We had the Philadelphia Electric stability program. So, we had sufficient amount of tools to carry that out.

Julie Cohn ([11:43](#)):

Were you using analytical computing machines or digital machines?

Vijay Vittal ([11:48](#)):

Digital machines. VAX/VMS was a regular—it was not a large digital computer. But it was a medium scale digital com—but could have enough ample computing capability.

Julie Cohn ([12:01](#)):

Around what year was this?

Vijay Vittal ([12:03](#)):

This was probably '84, '85—until the '90's.

Julie Cohn ([12:08](#)):

Because that was kind of a tipping point for the industry switching from analog to digital computing.

Vijay Vittal ([12:15](#)):

Correct. We did have a large IBM360, but that all worked on punch cards. You took the cards at night and if you made an error in the card, then you had to redo it the next morning. You would not find out that you had made an error until the next day.

Julie Cohn ([12:32](#)):

So, was Dr. Chiang a collaborator or—?

Vijay Vittal ([12:35](#)):

No, he was a fellow PhD student at that time. He worked with a faculty member called Felix Wu. And a lot of people used that particular result to make the—now, the method he came up with was useful in pointing out the direction. But it had a lot of numerical instability, because he came up with this lower order dynamical system, which could be used to move towards the unstable equilibrium point. But in terms of the dynamics: it's geometry; it was a very thin surface; you could easily fall out of it. So, you had to actually trace down this manifold and go towards the unstable equilibrium point. I had a student at that time who came up with a very nice technique to actually stay on the surface. And that's what allowed us to go and hit the controlling UEP very fast.

Julie Cohn ([13:45](#)):

So, you were working—?

Vijay Vittal ([13:46](#)):

He called this method shadowing, and he used this method very effectively.

Julie Cohn ([13:53](#)):

Who was that?

Vijay Vittal ([13:53](#)):

This was a student called Roger Treinen.

Julie Cohn ([13:56](#)):

Oh, is he someone you still—?

Vijay Vittal ([13:58](#)):

He is actually—he works for a company in Phoenix. We still keep in touch.

Julie Cohn ([14:03](#)):

Oh, that's great. So were there other people, you mentioned some people who were your advisors or mentors as you were going through your educational process? Were there others with whom you collaborated on this particular work?

Vijay Vittal ([14:16](#)):

Several people. There was a gentleman sitting there Gabriel Ejebe. Gabriel Ejebe was the lead from Siemens Empros. And so, we built the basic structure for this shadowing method. And they actually implemented in real time, in the energy management system. So, the other big name, who was a consultant to that project was Bill Tinney. So, Bill helped with all the final numerical techniques to implement it in the energy management system.

Julie Cohn ([14:51](#)):

Was that when he was at Bonneville?

Vijay Vittal ([14:53](#)):

No, he was a private consultant by that time.

Julie Cohn ([14:55](#)):

Oh, okay. I was going to say that was an interesting combination of industry sectors working academia, industry, government. But it sounds like the government piece was not there anymore.

Vijay Vittal ([15:10](#)):

So actually, the original support started with EPRI. They supported for a long time, then they wanted to implement this on a larger scale. So, there was a project where we worked with Ontario Hydro, because they were the utility where we demonstrated it on a larger scale.

Julie Cohn (15:28)

Interesting.

Vijay Vittal (15:28)

And then once we showed that it worked there, they wanted it actually implemented at a control center. So Northern States Power was our partner, and they said, “Yes, we would like it.” And then Siemens Empros was the one who had developed Northern States Power’s energy management system. So, they became the natural partner, and that’s how we teamed up with that.

Sairaj Dhople ([15:52](#)):

So, what was the chicken and egg like? Like was industry driving most of these investigations or was that academic curiosity which led you to contribute to control theory and then that resulted in solving application-specific problems? Or is it hard to kind of tease these two apart?

Vijay Vittal ([16:10](#)):

It’s—at that time, like, the system was growing. They needed faster methods to do security analysis—at least approximately accurate methods. That was driven by industry. The Dynamic Security Assessment working group has lasted since then. So Fuad was the first chair for that. It came under the PES System Dynamic Performance Committee. And so, it is still continuing to go on today.

Sairaj Dhople ([16:36](#)):

And for the benefit of the audience, maybe you can tell us a little bit about PSDP and—

Vijay Vittal ([16:41](#)):

So, PSDP is a committee within the IEEE, Power and Energy Society, which primarily deals with various aspects of dynamic system dynamic performance in power systems. So, it deals with aspects related to various types of stability, angular stability, frequency stability, voltage stability. So, they're the ones who formalize definitions for these three kinds of stability problems. And then work actively towards developing methods to assess and also develop control to prevent instability in these three forms. So that is the largest technical committee, which works in this area. And under the technical committee, they have two large subcommittees. One is called a Power System Stability Subcommittee, and a Power System Control Subcommittee. And then they have working groups under these subcommittees, which deal with specific problems. So, the Dynamic Security Assessment Working Group is a working group under the Power System Stability Subcommittee.

Julie Cohn ([17:52](#)):

As a historian, I have to ask this question: you described three different ways of characterizing stability, do you have a sense of when people thought about stability in that way?

Vijay Vittal ([18:09](#)):

Originally? In the days when they started off with the synchronous machine as the primary source, there was this issue of—systems were not interconnected. They were largely separate entities. See, in that sense there was this problem called hunting. And they very soon found a solution to this. But then I think people realized that, with the fact that in the US we had different time zones and load peaks occurred at different times of the day, interconnection would actually help in operating the system more reliably. And that's when they came up with the idea that neighboring systems could help you if you were interconnected. And that's how the interconnection grew. Other, other than the fact, like you showed that we have this geographical barrier in between the two large portions of the United States.

Vijay Vittal ([19:23](#)):

So, the Eastern interconnection and the WECC were formed and that's how they began to operate. And they found out reliability improved significantly. So that's how the, that interconnection took place. But then depending upon the characteristics of individual portions of the system, people noticed that large disturbances caused one type of problem. And that to large disturbances, which basically dealt with either large imbalance in active power caused one type of problem. And then there were problems related with lack of reactive power support, and that's how they came up with voltage stability. And then large disturbances in active power—whether you lost a generation or you lost a load, that basically related—I mean resulted in frequency instability. So those are—those were the three.

Vijay Vittal ([20:34](#)):

And the PSDP Power System Dynamic Performance Committee was the one who came to characterize these three and came up with this paper where they classified and defined each one of these stability aspects. So, over the years, that took a long time to actually formulate and come up with something constructive. And it was only in the 2000's that we came up with this paper. And that paper was jointly done by IEEE PES and CIGRE in Europe, so both of them contributed to it. And that was only revised two years ago when the inverter-based resources came in. We had newer problems arise, so we revised that paper again.

Julie Cohn ([21:27](#)):

So, were there significant dead ends you encountered while you were trying to work out how to address these issues?

Vijay Vittal ([21:38](#)):

Yeah, I think in research you always use dead ends. So, there were some tough periods, especially how to—this method I talked about, tracking to the closest UEP, the final step is actually to solve for this UEP. And solving for that is a highly ill-conditioned problem. It is a nonlinear algebraic system of equations. So, solving them requires some special skills. So, we

had to rely on a lot of material which was developed in other fields to apply them to power systems.

Sairaj Dhople ([22:22](#)):

And by other fields, you're talking specifically about other mathematical—?

Vijay Vittal ([22:26](#)):

Yes.

Julie Cohn ([22:31](#)):

So, do you feel like there's a, is there now a standardized solution to this? You've mentioned more than once that this is still an ongoing—

Vijay Vittal ([22:42](#)):

So, we came up with this method. We applied it. It was tried and tested. But by that time the computing computation power had increased so much what we could do that time with medium-sized computer or a large-scale computer, we essentially can do today with the desktop. So—and then the Sun Sparc stations came, and they were even more powerful than what we see today with—more expensive. So as a result of which, and then Northern States Power at that time started using what we developed as a screening tool. They used it in [an] approximate manner to determine what were the more critical contingencies, and then simply used full-blown time domain simulation to actually determine whether they would be stable or unstable and verified it in that sense. So that didn't go to waste, but in real time you could actually do time dimension, or just half an hour look ahead. You could do time domain situations.

Sairaj Dhople ([23:50](#)):

What is your sense for the role of analytical methods in today's context? I mean, it seems to me that there is computing power, but the diversity of resources and the nature of the system has changed in such a dramatic way—that—do you sense that analytical methods still hold that importance?

Vijay Vittal ([24:08](#)):

So, one of the drawbacks with the, at least the analytic method we were working with was the modeling capability was limited. There are certain sign definiteness conditions, which you needed to apply. But as you had more features, added more features into the model, like say, excitation system. So, governors were very difficult to prove those sign definiteness properties. Whereas with time domain simulation, that does not exist. So that's why whatever model where we could prove this was used as a screening tool, we then identified the critical contingencies and simply ran the critical contingencies with full blown detail in time domain. So that was the approach we took.

Sairaj Dhople ([24:56](#)):

And you see that as being an approach that should be reproduced for today?

Vijay Vittal ([25:02](#)):

So, I think Powertech Labs is one of the companies now which has a real online dynamic security assessment tool, which they're used at many utilities around the country. And they essentially for following that principle.

Julie Cohn ([25:24](#)):

So, over the years, it sounds like there were multiple venues in which you worked on issues with colleagues. I'm assuming you presented papers on the problems you were trying to solve. Do you think, would you say most of the sort of intellectual interaction with people outside your immediate research group was in conferences? At casual meetings? How would you describe that?

Vijay Vittal ([25:56](#)):

Conferences, a lot of conferences. Conferences here. I was also a member of IEEE Circuits and Systems Society. Met a lot of people there, automatic control conference, different areas. So, after a while, conferences became burdensome. So, I just stuck to one society and continued working there.

Julie Cohn ([26:20](#)):

And because you were working with Siemens, did that mean that other industry players were less interested in following your work? Or were they not that proprietary about their role?

Vijay Vittal ([26:31](#)):

I think once the techniques came out, other people also adopted, these other EMS vendors also adopted this. Oh, yes. Yeah.

Julie Cohn ([26:42](#)):

Do you all want to discuss other technical topics?

Sairaj Dhople ([26:53](#)):

Honestly, I think this one is probably the most interesting one in the context of where the grid is today and where we see it evolving. So, maybe do you have a sense for any comments you want

to offer on that front? Where, where do you see are important challenges that we should be addressing in order to achieve our goals?

Vijay Vittal ([27:15](#)):

I think with inverter-based resources as we have been discussing today, there are a number of complexities as to what would happen if their penetration increases, a beast of a different nature. And topics we were discussing today are pretty relevant. How do you develop suitable models? How do you verify these models? They are—they act at a different timescale than conventional synchronous machines. So, what type of simulation is required? That people—is some kind of mix of representations good enough? So those are some questions, I think which we are addressing today and need to be addressed to pin down what exactly will happen with these devices.

Sairaj Dhople ([28:17](#)):

So, when you see this and you think about it, do you get a sense that history is repeating itself? Like in the beginning?

Vijay Vittal (28:22):

More or less?

Sairaj Dhople (28:25):

You had the load growth somehow in- informing your early work, and now you have the switch to renewables, or at least the hope to switch to renewables informing this part of your career.

Vijay Vittal ([28:35](#)):

Correct. And I have—so in the last few years I've been looking at a lot of modeling renewables, both wind and solar.

Julie Cohn ([28:42](#)):

But even looking back between the 1970s and today, there have been some other fairly significant changes in the industry and how electrification has been expanded. Deregulation, it's not really deregulation, but restructuring of the industry, restructuring of the regulatory regimes, various energy crises and non-crises, I think we will see even more because there is this big push towards electrification of transportation and transportation is the largest producer of greenhouse gases.

Vijay Vittal ([29:11](#)):

So that is going to be a big challenge for the grid. How do we handle this electrification of transportation. And then there is this other big push now by the federal government on decarbonization of manufacturing processes. They've identified five processes, which are, again, the largest contributors to greenhouse gas, and they were the big push towards electrifying them. So, all this additional load combined with a push towards renewables is going to make this problem very, very interesting.

Julie Cohn ([30:09](#)):

Yes. And probably an order of magnitude of complexity. When people who own electric vehicles become contributors as opposed to simply customers of power systems.

Vijay Vittal ([30:27](#)):

Yeah.

Julie Cohn ([30:29](#)):

So, we've talked about several aspects of this technical challenge. We've mentioned, or you've mentioned specifically, the move towards green energy and goals such as net zero. Additional

thoughts about how industry, academia, regulators, other stakeholders, will tackle these problems going forward?

Vijay Vittal ([31:04](#)):

At least right now where technology stands, I'm not sure in my own mind whether we will ever reach a hundred percent renewables, because I have a feeling with the way we operate an AC grid, there has to be some backstop in case of emergency. Either you shed load, or you bring on generation, which is dispatchable. So, there will be some amount of dispatchable generation all the time. It may not be coal, but it could be modular nuclear reactors. And they have—the NRC has licensed the first design, and if they do become a reality, I think it solves a lot of our problems. And, of course, hydro is there, but you need the natural resource to supply hydro to some extent. Probably the fallback will be natural gas for some time to come. Less polluting than coal, but it has the ideal characteristics in terms of speed of regulation. So, it'd be, there'll be some balance struck, I think. And that is what will hold the system up until we come up with the appropriate solutions.

Julie Cohn ([32:38](#)):

That's true. Other technical questions?

Manish Singh ([32:43](#)):

So, when you're talking about the problem of finding UEPs back then, were there other groups in the US or abroad who were working on the similar problem this time and you came up with solutions that were conflicting or mostly more consulted?

Vijay Vittal ([32:57](#)):

I think people were coming towards that same idea. But then I know finding this—somebody had to determine how to get to that. And I think Hsiao-Dong's work was very instrumental in that. But then the fact that the surface that he had described was pretty thin in terms of its geometry and you could easily fall off of it as you can. Tracking that and coming up with the method to actually head towards the right UEP was very important.

Manish Singh ([33:38](#)):

And in terms of, like you said, that even today, industry uses sometimes analytical aspects for the screening effort. So, on that part, how much the practice of today's industry changed from the findings of those days? Like what's being done today, is that very similar to what was done?

Vijay Vittal ([33:52](#)):

Very similar. I think they still use that because the screening method is fast and it kind of works well and at least gives you a ballpark picture of what disturbances can cause problem. And then you can go ahead and analyze them in more detail.

Manish Singh ([34:09](#)):

So, given that these energy functions depend quite upon the choice of model, and you were just pointing out how models will change in future because of the inverters and renewables, do you think this portion of the screening tools will again be revised with the new models?

Vijay Vittal ([34:22](#)):

I think they will use some approximation again, like we did—say if you use classical synchronous machine model, they will use some basic model for the IBRs, which captures what they will do, and then at least make sure that the energy function satisfies all the requirements for them. And then move up to a more detailed model in simulation.

Julie Cohn ([34:50](#)):

Well, I have one last question for you. What would you like the general public to know about the work that you've done?

Vijay Vittal ([35:02](#)):

I think it paved the way for at least examining how people look at systems and gave some insight as to how dynamical systems behave. And then I think it allowed industry to actually come up with techniques which are applicable, and they have used in practice.

Julie Cohn ([35:39](#)):

Thank you. I think that's very significant information for the public to know.

Vijay Vittal ([35:45](#)):

Thank you.

Julie Cohn ([35:45](#)):

Are there any other topics you'd like to discuss?

Vijay Vittal ([35:49](#)):

I looked up to a lot of people. I know a lot of people were the inspiration for this work. My advisor in India who introduced me to this topic, the person I came and worked with [Aziz *Fouad*], Tony Michel, and Dick Miller, who allowed me to build my background in this area. And then at the PES meetings, I met some outstanding people. Charlie Concordia was one of them. He was—he would talk to anybody and everybody. So, there had not been a meeting that I had

not talked to him and heard, heard him for at least an hour giving some bit of information which was useful. Then Prabha Kundur was another person who was inspiration. And then a lot of people in the Power System Dynamic Performance Committee who provided bits and pieces of information which made a big difference.

Sairaj Dhople ([37:02](#)):

So, it's very heartening to hear you give credit to people that inspired you, but, and you are a source of inspiration to the generation that follows you. Do you have any words of advice for people that look up to you?

Vijay Vittal ([37:20](#)):

So, one of the things—I had good mentors and the advice they gave was, when you come to these meetings, just don't go attend paper sessions, but go to the technical committee meetings where they actually discuss some of this stuff. So, I think young people should get involved in that. So, I advise my students to actually go to working groups, volunteer to actually take part in that. So, my first effort was we were working on this and Dick Farmer, who was another source of inspiration, was the chair of Power System Dynamic Performance. He set up a working group where he said, "We need to have a working group which will actually create a practical test system to look at stability." So here, a person whom he appointed as chair, I was part of the working group, and that person became too busy. So, I became the chair and that was my first piece of work to actually build a stability test system, which many people use now. And that's how I got into it. And I was actually an assistant professor at that time, so that was a great experience, and I suggest that to my students even today. Then go volunteer and start doing some of this. That played a big role in people beginning to know you and knowing that you could actually do something about it. And I think that's very important.

Julie Cohn ([38:49](#)):

That reminds me of something I meant to ask you earlier, if you don't mind?

Vijay Vittal (38:53):

Sure.

Julie Cohn (38:54):

One more question. So, when you were deploying your approach from the more theoretical model that EPRI, you developed with EPRI at Ontario Hydro, how did it go?

Vijay Vittal ([39:09](#)):

Oh, I was in Toronto every month.

Julie Cohn ([39:14](#)):

I mean, did it work?

Vijay Vittal ([39:17](#)):

There were hurdles, but I think we eventually solved all of them. And they actually tested it on their system, and the stability test system actually came out of Ontario Hydro system.

Julie Cohn ([39:28](#)):

So, were there, like, cliffhangers, like you started using something and then you wondered was this going to cause a major problem? Or did it not have that kind of—?

Vijay Vittal ([39:40](#)):

No. No, I did—it did not have that kind of thing.

Julie Cohn ([39:42](#)):

Alright. Just curious. Well, thank you very much. We really appreciate your time and your work in this field and the contributions that you've made for all of us.

Vijay Vittal ([39:59](#)):

Thank you.

[End of interview]