Algorithms & Power Systems Architecture:

Using Historical Analysis to Envision a Sustainable Future

Oral History Project

Interviewee: Nikos Hatziargyriou

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Interviewer(s): Mahbubul Bhuiyan, Sairaj Dhople, Manish Singh

Julie Cohn was also present for the interview

Transcriber: Temi

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***Abstract*:**

Nikos Hatziagyriou, Ph.D., is Professor Emeritus at National Technical University of Athens. In this interview he describes his educational background, his dissertation work on control centers and the use of graphical interfaces and calculating short circuits. He describes his positions at Public Power Corporation (PPC) and the Hellenic Electric Distribution Network Operator (HEDNO), both in Greece. He discusses operating power systems on the Greek Islands, his contributions to the field of power systems operations through the distribution of smart meters, the application of GIS, and the advance of distributed energy systems. He notes that the islands can operate with up to 70% penetration of renewables, on an annual basis. He mentions the possibility of using inverter-based resources for blackstarts. He focuses on his research group's contributions to the development of microgrids in Europe. He considers the interactions between industry and academic engineers, especially with regard to participation in association meetings and publication. He urges more communication between the two sectors. He names several mentors and influential engineers in his own work. He discusses the current transition from traditional thermal generation to solar generation and the policies and

technologies at play. He notes that microgrids are essential to distributed generation. He closes by urging young people entering the field to do something they love and devote their efforts to technologies needed for a more resilient and fair society.

Note regarding Transcript and Timestamps:

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

Transcript:

Mahbubul Bhuiyan (00:01):

Thank you so much for giving your important time.

Nikos Hatziargyriou (00:05):

It's a pleasure.

Mahbubul Bhuiyan (00:07):

This is Mahbubul Bhuiyan. I'm conducting an interview with Nikos Hatziargyriou on Tuesday, July 18, 2023, at the Hyatt Regency Orlando, in Orlando, Florida. Dr. Sairaj Dhople and Manish Kumar Singh will assist the interview and Dr. Julie Cohn and Dr. Daniel Molzahn and Rachel Harris are also present here, and they may also ask questions. So, during today's interview, we are especially interested in how a data operator integrates evolving algorithms for control and optimization and how you have seen what, on these topics, unfold in the literature. So, we'll begin with some introductory questions and general background information about you. So please describe your educational background and your professional positions in the field of power systems.

Nikos Hatziargyriou (01:07):

Okay. I have finished my undergraduate studies at National Technical University of Athens. Then I did my master's and PhD at the University of Manchester in UK. When I came back, I became professor at National University of Athens. I became full professor in 1995. And I am retired since—end of 2021. From February 2007 to January 2010, I was Executive Vice Chair the Public Power Corporation, which is

the utility of Greece, the integrated utility at that time. And I was also Vice Chair [*Deputy CEO*]. And from February 2007 to September 2012, I was Deputy CEO responsible for the Division of Transmission, Distribution, and also of the islands—islands operation. Also, from April 2015 to May 2019, I was chairman and CEO of the Hellenic Distribution Network Operator of Greece. This is the only DSO in Greece. And we were also responsible for the operation and planning of islands.

Sairaj Dhople (02:42):

So, Nikos, you mentioned a few different organizations on the industry side, cutting across transmission, distribution, utility system operator. Can you tell us a little bit about how all of these play together, increase, and how they're all organized?

Nikos Hatziargyriou (03:01):

Yeah. At the beginning, the main company dealing with electricity supply, and also networks, was PPC, the Public Power Corporation. That was then the incumbent integrated utility. After deregulation was applied, that was in 2015, then the distribution part of the company has formed—a partially independent company—called HEDNO, Hellenic Distribution Network Operator. That was, however, subsidiary 100% of the PPC. And its responsibility was to develop, maintain, and operate distribution network, including the islands that were also part of distribution. But in that particular case, they were also responsible for the market operation of the islands.

Sairaj Dhople (04:09):

And you referenced islands a few times. Of course, Greece was blessed with so many different islands. So, are the problems there unique? Like, is the way the grid there managed different from the rest of the mainland?

Nikos Hatziargyriou (04:22):

Yeah, I mentioned particularly islands, because indeed Greece has, at the time had 32 independent islands, or island groups, that faced their own challenges in their operation and planning, but mainly in operation. And as you know, islands have not the support of neighboring systems. So, the problems of—especially frequency—and the problems of coordination with these units was particularly challenging, especially in view of increasing the renewables penetration of these islands. Also, islands in Greece do not have their own resources. They have to be based on diesel. That is important—expensive and

polluting. So, it put a lot of sense to develop renewables. And something that was particularly challenging and satisfying in my career was to see how we develop algorithms that could operate the islands with high penetration of renewables, keeping the security constraints, and increasing renewables at the same time.

Sairaj Dhople (05:47):

And I suspect we'll get to that in the next part of the conversation.

Mahbubul Bhuiyan (05:50):

Yeah. So now we would like to know more about your significant contributions to the grid operations. So, what was, what has been the most important technical problem you have tackled during your work?

Nikos Hatziargyriou (06:12):

Okay. In my career as CEO of the distribution utility there was a number of challenges. Not only technical, but also organizational. So, it was important to develop strategies and roadmaps so you could move to the new era of the next transition by looking at the digitalization of the system, by trying to move several—organize and execute several projects towards this direction. So, I think one of the main contributions at the time was to organize this transition for developing a number of strategic projects that are still being executed and being realized in the distribution utility of Greece. This included activities like installation of smart meters, wide application of GIS, and several levels—very important projects about the organization of the distributed—of the distribution—DMS systems. So, they could eventually also exploit the flexibility of distributed sources. The planning problem, how we could increase the hosting capacity of renewables at the distribution level without resorting to unnecessary investments. So, these were main areas that at least they were planned. There were several important steps done. Among these projects, one of my favorites was the scheduling of the energy islands, the smart islands. Which meant how we can operate islands with a very high penetration of renewables, which means operation beyond 60-70%, 70% of renewables an annual base. That was challenging because, you know, more than 70% means that for several hours of the year, the system should operate with 100% renewables, so only inverter based.

Nikos Hatziargyriou (09:05):

And of course, storage. So, we have thought of hybrid stations and how they could support frequency and voltage. So, at that time, that was quite, quite, let's say, unique. We did not still discuss, quite discuss today about grid-forming capabilities of inverters. And, and in fact various vendors were describing solutions, were not convinced, especially how they could blackstart the system only with inverters. So that was, I think, a very interesting area of work.

Sairaj Dhople (09:59):

Did that ever have to be done? Did you have to blackstart an island?

Nikos Hatziargyriou (10:02):

Sorry?

Sairaj Dhople (10:03):

Did you ever have to blackstart an island?

Nikos Hatziargyriou (10:04):

No, this—I'm telling you about my plans, not about what happened!

Sairaj Dhople (10:08):

Okay. <Laugh>. Okay.

Manish Singh (10:09):

So, so the problem definitely sounds very rich and intricate, but in, within these issues, what were the most challenging ones? Were they on the control fronts or communications or optimization and dispatch, power flow, because it seems like a problem that involve all of these things.

Nikos Hatziargyriou (10:24):

Yeah. Indeed operation, even at the level of conventional, let's say, technologies, was not the same. It was more difficult, because the way you would forecast renewables in small systems is much more tricky than it is in larger systems—which have the smoothing effect. Also, the way you operate the system with maintaining the right level of spinning reserve has a very important effect on the cost of the

system. And here you don't have many units to play with. You have relatively smaller units. So, these have quite important consequences. Now when you increase renewables, then also these dynamic problems appear and how you could now integrate the security constraints in the typical unit commitment problem needed some original ideas.

Manish Singh (11:35):

Just out of curiosity, like, are island grids a miniature version of mainland grids, in terms of the architecture of control, do we see primary, secondary, tertiary, all these types of controls on island grids as well? Or are they operated in a very different way?

Nikos Hatziargyriou (11:49):

Well, in very small islands you can say that it's mainly primary control. And also, to be honest, the power quality constraints are not that strict than these connected systems. But of course, you know, nobody likes going to blackout frequently for that. So, so yes. And by the way, I must say that one of the main—now I changed my hat and speak as a university professor—one of our main contributions as a team was in the development of microgrids in Europe. We were one of the first research groups that developed—not developed, but followed, the idea of microgrids. And we have done some quite pioneering work in developing ideas in laboratory and also in actual islands. So, islands have inspired us also to develop this technology for microgrids, which are part of the distribution system that of course are not always islanded, but they do have the capability of running islanded. And then they have similar problems like islands.

Sairaj Dhople (13:15):

Nikos, I just want to take you back to your PhD. Can you tell us who your PhD advisor was and what your PhD thesis was about?

Nikos Hatziargyriou (13:23):

Oh, that was a long time ago. My PhD was about control centers, EMS, and we looked at—we focused mainly in the area of the graphic interface and on the, how you could calculate short circuits and the special—take into account the DC component in fault. My supervisor was Professor Saki Efthymiadis, at that time.

Sairaj Dhople (14:01):

And you already are taking us in this direction of the interplay between industry and academia. Would you say that the work that you did for the islands, for instance, was that informed by your research or did it come from the needs of just supplying power? So, was there you know, an immediate need that industry brought about, or were you excited to try out things that you knew from your research that you wanted to, to deploy?

Nikos Hatziargyriou (14:36):

That's a good—I think there is interplay of this. You can't say that the one has not affected the other part, although these are two different worlds. When you are, of course when you are responsible for a company you don't have time to think of research. There are many more pressing and non-interesting duties you know, and, but still I think my involvement with academia has given me the opportunity to better understand technical problems and understand what the engineers of the company were suggesting and what the direction should be. So, yeah, I would say it is mutually beneficial. And then when I came back to university, again, I think my research was much more grounded, rather than developing let's say more theoretical ideas that could not be really applied.

Sairaj Dhople (15:45):

And what prompted your return to academia? Were you just missing the, the pen and paper analysis, although you did say that you were more—

Nikos Hatziargyriou (15:51):

No, my, my term was finished. Okay.

<laughter>

Nikos Hatziargyriou (15:55):

This position, you don't give them forever—have a specific time.

Mahbubul Bhuiyan (16:01):

Can you tell us a little more about, during your career, with whom you collaborated? Can you mention some people from the industry or academia?

Nikos Hatziargyriou (16:13):

During when?

Mahbubul Bhuiyan (16:14):

During your career in academia and work, whom did you collaborate with? Is there any person?

Nikos Hatziargyriou (16:23):

Persons?

Mahbubul Bhuiyan (16:23):

Yeah, from the industry and academies?

Nikos Hatziargyriou (16:26):

Well, I have, many people have collaborated. Believe me, I can't really mention somebody and be fair. For sure, a person that has inspired me a lot was Prabha Kundur, who has really helped me to understand better the power system dynamics. My own mentor, my professor Basil Papadias.

Nikos Hatziargyriou (17:04):

My good friend George Contaxis. all these people who have passed away, but I have high respect for them. But many more people. You know, currently I work with Sairaj for one of them, and

<Laughter>

Sairaj Dhople (17:22):

But in a much smaller capacity, right?

Nikos Hatziargyriou (17:24):

Yes. But yes, but very, very important contributions.

Mahbubul Bhuiyan (17:28):

Can you tell us a little more about, you know, what area or, you know, what problems did you work with them, the persons you mentioned just now?

Nikos Hatziargyriou (17:44):

Okay. Since I have worked a long time in research and industry, I have dealt with several areas, and I have done research from EMTP type of dynamics in the first years. That was where Professor Papadias introduced me to this, to the EMTP type of studies. And then I worked for dynamics and Prabha Kundur was one person, but many more people. And then I also later worked on optimization. Again, learning many things from various colleagues. And then my colleagues were, again, I had very good collaborations with groups of people from UK, Portugal, France, and—.

Sairaj Dhople (18:44):

So, you know, you mentioned your work on microgrids. Of course, it's very highly cited and it's one of the early works in the area. I was just wondering, did, in terms of timeline, did that come before your experience with operating these island grids? Or was it informed by your expertise in working on these island grids?

Nikos Hatziargyriou (19:03):

We worked in research for islands. First funded by European projects and by niche of islands. And then from that we moved to the microgrids area, again leading the first large—two major projects in Europe about microgrids, called Microgrids and More Microgrids. And after that, later on I moved to industry, and then I had the chance to, again, work on islands. It was too early to speak about microgrids in the industry because, you know, it's, it looked, it would look a bit out of any realistic, let's say, plan. But yes, all these so this was a sequence from islands to microgrids and then back to islands and back to microgrids.

Sairaj Dhople (20:02):

I have a couple of other very general questions. You come from NTUA and it's incredible the level of power engineers that NTUA produces. What's the secret?

Nikos Hatziargyriou (20:15):

That's a very good question that I—I think that the secret is that we have a very strong first year background in mathematics and economics—in mathematics and physics. So, whatever the changes in technology are, we are, our students are able to adapt to these changes and understand technological advancements. We don't focus too much on specific technologies. And sometimes we are criticized for that, especially students feel that the first years are heavy, and too difficult and too—not so interesting, as it is to play with, you know, the largest computer,

Sairaj Dhople (21:02):

Can you give us a sense of how challenging it is to get through those first few years at NTUA?

Nikos Hatziargyriou (21:08):

It is quite challenging. I mean, students really have to work a lot. And I must also add that our university attracts the best students in Greece, so only top students can enter the exams. So that, of course, is a big reason for success. As a professor, I must say that when I have a PhD student, very early I start learning from them. After one year, or two years, they teach me <laughter>. I just only say, well, the direction is okay. But they do a lot of original work.

Sairaj Dhople (21:55):

And of course, you've been involved with technical societies like PES over a very long timeframe.

Nikos Hatziargyriou (22:01):

That's right.

Sairaj Dhople (22:02):

What, what do you see are changes that have happened with, let's say, the way conferences have been organized in terms of the publication process over the many years that you've been associated with, with the PES, and how do you see it proceeding in the future?

Nikos Hatziargyriou (22:17):

Okay. There are obvious changes to the technological advancements, of course, but I still have a very high respect for the PES publications. And I think they are really the best—the best resource for learning in our profession. So now obviously you see more and more work on cyber, physical system integration. You see more work on power electronics, more work on artificial intelligence. But overall, I think there is nothing wrong with that. I mean, I think PES really leads the industry and is extremely useful for, obviously, for academia, for the academic work, but also for the professional work. I mean, it's true that we don't see too many industrial persons writing papers and getting involved, but this should be understood by the—really—pressure they have, and the lack of time, the lack of also any incentive to spend time.

Sairaj Dhople (23:33):

Do you think it's always been that way, or do you feel like over the years that has changed?

Nikos Hatziargyriou (23:38):

Yeah, you're right. This has changed slightly. I mean, in the last years, we see less and less industrial people being involved. In my own, in my earlier times, you could see more industry being authors or reviewers, you know, or officers of the committees. But this is due to the increasing pressures of professional life today. I don't think there's lack of interest to do these things or of people thinking that it's not worth doing it. On the contrary,

Mahbubul Bhuiyan (24:20):

You worked in different positions as the chairman and CEO of Hellenic System Distribution and in the Public Power Corporation of Greece? So, can you tell us a little bit about the policy implementation? What challenges you faced regarding the policy encountering the <inaudible>?

Nikos Hatziargyriou (24:45):

Well, several challenge of course. First the move from coal to renewables. The gradual transition has been, of course, very challenging. There was a big—big discussions and arguments about—also think that at that time, renewables were not so cheap. Coal was an obvious source, also preserving the security supply. Although it was polluting and that was normal. So, there was a little discussion where the investments should go, how the partnerships with other big utilities should happen. So, this was one big challenge. Another challenge was how you would deal in the market with the competitors and how

you could operate a public company that had to face the competition. And then, the biggest challenge was when I was called to be CEO of the—Chairman and CEO of the distribution company. And that had to—apply deregulation. So, moving from a department of a company, making an independent company, this is quite challenging.

Nikos Hatziargyriou (26:42):

My idea was always that the DSO should be independent from the generation because they have obvious different philosophy, different mentality, but this was not easily understood. And, we had, I had big, let's say, opposition, or challenges.

[REMOVED FROM THE TRANSCRIPT]

And also it was how you see the role of the DSO, you know, for me, a distribution company, which is run as a monopoly and offers such a high importance. The important thing is how you always provide the best services at the lowest cost with increasing renewables, while keeping the economics at the satisfactory level, but without having as first priority to make profits. And that's not, let's say, generally agreed. But my idea was to have—idea—so that was really serving the people. And that also created some challenges.

Sairaj Dhople (28:07):

Can you think of some best practices to make sure that research that we do is aligned with where industry wants to head, even if it's not immediate to their interests? What can we do better to make sure that we are working on the right problems?

Nikos Hatziargyriou (28:34):

I say that this is not developing in this direction. I would obviously suggest that better contacts with industry would help. So, our research is better serving the industry's needs. And this is a, I would say, a problem. This is something that industries together with universities should really seek for. It is true that, in many parts, there is still some type of misunderstanding or mistrust between industry and universities. Industries many times feel that universities do things that are not really relevant. Universities feel that industries do boring things and, you know, it's not, they're not progressive enough to understand the big ideas. So, there should be some more interaction, but the primary step should be done by the companies, by the utilities. And lately I see a lot of interesting steps, interesting directions

towards this. And—for instance in Europe, several utilities or operators do this—organize meetings and try to understand what the universities are doing and try to provide some guidelines. In Europe, I would say, for instance France has done some very interesting ideas. We also tried to copy some of them, and we did some steps

Nikos Hatziargyriou (30:30):

And other utilities, of course, in Europe also do that—Spanish, Italy.

Sairaj Dhople (30:36):

So, it seems to me there is a love of power engineering that's, that's embedded in you because you didn't, you know, necessarily chase industry entirely. You didn't chase academia entirely. You did all of these different things, but it all came from excitement for the power engineering area. Can you take us back to the origin of that excitement and why you chose this area to pursue your education and your career?

Nikos Hatziargyriou (31:08):

That's a difficult question, psychological question. I don't know, I cannot say that—during my undergraduate studies I really liked the topics of power systems. Perhaps it was because of my professors, but also, I believe that the energy is, has a fundamental social value. And at the time it was obvious to me that it was, you know, even more important than information or telecommunication. So that was also one of the reasons—I liked energy and I got interested and at the end I spent most part of my life studying and doing research in this area.

Mahbubul Bhuiyan (32:01):

So now we'd like to shift a little bit to some question about the broader impacts of your work over your career. So, the first question is: you have done a lot of work on microgrids. So, to what extent do you see the solution we have today as appropriate for the future power system?

Nikos Hatziargyriou (32:28):

Yeah. I see that distributed generation that is increasing all over the world leads to a decentralization of the thinking of the control of the system. And in fact, as more and more you need to involve small distributed units, this is the only way you can do it. I mean, you have to decentralize the system. And I

mean, decentralization becomes more effective and more efficient and more secure. So microgrids is one form of decentralization. I mean, it's how you can organize, how you can control, and how you can coordinate a number of resource units at distribution level, so that they can be better—they can better serve the overall system. In the last years, this is becoming more and more obvious, as we need to protect the system from catastrophic events due to climate change. So, you see how microgrids can increase the resilience of the system. And really today they are understood, from the companies, from the utilities, as a main as—no as an effective means to increase resilience.

Nikos Hatziargyriou (34:10):

Also, I think that microgrids play the role of the technical support for energy communities, which is another area that is developing again, all over the world, but in Europe, a lot. Also, a measure to fight energy poverty and to make people more aware and more involved in the next transition. So, I believe microgrids eventually will play increasing role in the power system. By that I don't mean that we will have the system that will be fully microgrids, only, you know, such systems that will collaborate, et cetera. I believe that there will be a large grid that will be used to tap the large potential of renewables and bring the power to the basic consumption centers. So, there will be always some equilibrium, some symbiosis between the large super grid and the local coordinating microgrids—coordinated microgrids. But it makes sense also to think that you can increase the security and resilience of the system by investing in the intelligence of the lower grid, rather than building only large infrastructures, but also more vulnerable to the catastrophic events. So, the optimal equilibrium is, needs to be found, is not found yet, but needs to be found.

Mahbubul Bhuiyan (35:54):

Do you have any other questions regarding this?

Sairaj Dhople (35:57):

I guess I'll ask a parting question, Nikos. Do you have any words of advice for the next generation of power engineers, be it academia, industry, you've seen both ends of the spectrum?

Nikos Hatziargyriou (36:11):

Well, that's, I would never give such advice. I think young people should prefer what to do. They should love what they do. They should devote all their efforts and try to develop technologies that are needed

for a more resilient society, more fair society. And this is the only advice I can give, I mean to love what they do and to devote all the efforts to do it the best way.

Sairaj Dhople (36:52):

Thank you so much.

Mahbubul Bhuiyan (36:56):

Okay. Thank you so much for the—you managed this time for us. So knowledgeable. Thank you so much.

Nikos Hatziargyriou (37:04):

It was a big pleasure. Thank you very much for the invitation.

[End of Interview]