IlLUminate Blog Transcript: **Alberto Lamadrid – Lessons from the Texas Energy Grid Failure**

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JACK CROFT: 00:14 Welcome. I'm Jack Croft, host of the iILUminate podcast for Lehigh University's College of Business. Today is March 3rd, 2021, and we're talking with Alberto Lamadrid about the recent massive failure of the Texas electrical grid and what lessons we should learn from it. Dr. Lamadrid holds the Class of '61 professorship in economics and is principal investigator on an interdisciplinary faculty team at Lehigh University's Institute for Cyber Physical Infrastructure and Energy that, last year, was awarded $2.5 million in funding by the Advanced Research Projects Agency - Energy, of the U.S. Department of Energy. The funding supports the development of a framework and platform for asset and system risk management that can be incorporated into current electricity system operations to improve economic efficiency. And we'll be talking about that some today. Welcome, Dr. Lamadrid.

LAMADRID: 01:13 Thank you.

CROFT: 01:14 The massive power outages that occurred in Texas in mid-February left millions of homes and businesses without heat, electricity, and water for several days. And the death toll related to the harsh winter storms and the outages they caused are still being calculated. What convergence of factors caused such a large-scale failure of the Texas electrical grid?

LAMADRID: 01:35 Thanks, Jack. And I think that that's a very good question. So there were a number of events that actually happened and created this sequence of cascading failures that occurred in Texas. You can call this relatively high-impact, low-probability events. But if we want to start from the very beginning, the triggering event was the fact that there were very low temperatures, beyond expectations, and that they were set for a sustained period of time. This created another set of dominoes falling, like the first one that I would say, is that the electricity system has very limited response in terms of the demand, okay? So what happens is that, even if there's going to be a number of events happening, for example, the fact that the temperatures are very low and people are going to be requiring more power in order to, for example, heat their houses, they really don't know; they don't have too much visibility about what is happening at the system level. In that sense, a lot of people may be putting their thermostats at a level that is comfortable. And you could think that when you start adding all of that demand, you may end up with a much higher level than you would have if you were, for example, in normal situations. So in that sense, if, for example, each one of the individual households dialed back, just a little bit, the temperature. So let's say they, instead, of putting it at 75 Fahrenheit, they put it at 60 Fahrenheit, and that was done over a generalized number of areas-- so like many cities-- that could have helped prevented the situation. But because the demand is not very responsive-- or because of the design, households and different consumers, they didn't have access to this information.

LAMADRID: 03:30 Second, there were a number of outages on the supply side. So what happens with Texas is there is a system that it's relying, still, very much on natural gas, and a lot of the infrastructure is not winterized. So what occurs is that imagine, for example, you're going to be a natural gas plant that is going to be generating, but you're not going to be having enough gas coming in mostly because, by regulation, this gas is prioritized for human purposes. So you send that gasoline-- we use gas for both heating our houses and for generating electricity-- you send gas to households or to centers that actually need it in order to start heating. But then you end up with a lot of households that may not have the gas heating; they are going to be using electricity heating. You end up with-- generators, actually, are not going to be having access to that natural gas, and therefore, they're not going to be able to produce. So that was one of the parts. There is also a lot of publicity regarding failures happening, wind energy. And that occurred, in fact, wind blades were not able to produce. There were even outages in terms of our nuclear plants, which are what we call base loads in the sense that they are relatively reliable. But because of these conditions, there was a lot of freezing water that could not be used in order to start cooling the nuclear reactions, and therefore, some portion of the supply went out. So that would be a second reason, the supply side. It was also under a lot of stress.

LAMADRID: 05:12

The third one is, in general, all of these design interactions that are occurring, like I mentioned already, the fact that the natural gas is prioritized for certain events, there were a number of other things that occurred, like, for example, there's going to be a spike in prices. And this, in certain cases, is going to be leaving some generators unable to keep up with those situations. And there's going to be a number of other, like, for example, the fact that they-- many households-- so Texas has been increasing in population during the last decades. And, historically, the way that they knew a stock of houses was being developed was using much more electric heating. So because of that, in many cases, they were using a lot of electricity. In many cases, these new houses, because they are rarely exposed to these kind of situations, they were not completely insulated. They were not properly insulated for these kind of conditions. And, therefore, people sometimes, since they don't have the heating, they start using, let's say, the oven. They open the door of the oven, and that creates even further demand. So the accident or the way that these assets-- again, no assets were entering into the system, creates these number of events.

CROFT: 06:39

You talked about the harsh weather that hit, with temperatures lower than a lot of people expected. And we've been hearing this phrase "Black Swan Event" popping up in news coverage all over the place in regard to the Texas power outages, with the meaning that the weather conditions were so highly improbable that they couldn't have been foreseen. I wonder, from your perspective, how foreseeable was what happened in Texas last month?

LAMADRID: 07:13

In general, it was a difficult situation. So I have heard about colleagues that are in Texas, and they seem to like-- there's temperatures that were extremely low, and the people that have been living there for 30 years, they've never seen them at this level. So it's something that was beyond expectations, again. And I think that that's what really puts you in trouble. On the other hand, one thing that actually occurred exactly 10 years ago-- so in February of 2011, there was also another cold spell in Texas, and around 60 power plants went offline. There were some people that actually had some outages and similar-- it was not as widespread as the one that happened now. But you could argue that there's been other kind of cold events. Actually, in the last decade, we have had at least five of these events.

LAMADRID: 08:02

We are here in Pennsylvania. Here, PJM, which is the system operator for our region, had a similar event in 2014. There were some stresses in the system, around 22% of the capacity was not available back then. So, overall, I would say that it is a rare event. I think that with climate change and with the weakening of the Gulf Stream and a lot of what is happening in many other regions-- actually, Madrid has had some snow in February, which is relatively rare as well-- we may have to re-evaluate what is a black swan. It's rare, but these kind of events may start occurring much more often. And in the case of electricity, usually, the requirement is that you should be able to withstand-- the regulation is one every 10 years. So technically, we're at the 10-year mark for the state of Texas. And the entity in charge of this is called the North American Electric Reliability Corporation. So they are actually subject to this kind of regulation. But we'll see if, maybe, with more frequent events, we're going to have to start re-evaluating what these criteria are.

CROFT: 09:17

And looking at Texas specifically, it is kind of a, not rare, but unique in the lower 48 states as the one state that operates its own electrical grid independently from the federal government. Now, there's been a lot of debate over this, whether that was a contributing factor to the outages, whether their independence ultimately would not have made any difference because the harsh weather was blanketing the country at the time, and it wasn't like other regions necessarily had extra supply they could have sent their way anyways. But so I'm just wondering, what's your view on the role, if any, that the independent system in Texas played in what happened?

LAMADRID: 10:08

I do think that it played a role. So it seems to me that if you had more interconnections, maybe the extent of what we have seen would have been lower. I don't think that-- as you pointed out, there were a lot of other regions around. So like the Southwest Power Pool, SPP, which is just above Texas geographically, they also had some outages. So in Oklahoma, they were having some issues. So it is possible if you are under these circumstances, and even if you were still connected-- much more heavily-connected-- you would be having some trouble. So Texas is generally isolated. And this comes down to-- back in 1935, there was something that was called The Federal Power Act, and that gave the federal government the authority to regulate the electricity sales between states. ERCOT, actually, was created and they-- it starts-- the genesis of ERCOT started in the 1970s. And from the beginning, they tried to avoid having some federal oversight. They are fiercely independent. So because of that, probably, they have limited the number of connections. It is not that they are completely independent. So actually, there is a number of high-voltage DC lines. So this, basically, allowed to start connecting point to point. There's also interconnection with Mexico. And in these situations, actually, they were not being used. Probably, we will have seen less of an impact. It is unlikely that we would have completely avoided what happened. And in general, you see that this was relatively unexpected. So because of that, the operators did the best that they could, given the system that they had. So in this situation, if they had had more interconnections, maybe you will have seen less. But it's unlikely that you will have completely avoided the situation.

CROFT: 12:11

Now, you touched on a couple of the main sources that were part of the problem, with the grid being natural gas and nuclear power going offline, to some extent, as the storm hit. And one of the things that's also been generating a lot of discussion is some people in Texas, initially, were blaming their move to some green energy as the reason that it didn't work, and that wind, in particular, did not fare that well. So I'm wondering, what are the main sources? What does that mix of energy sources in

Texas look like? And were there any of them, really, that fared well during those storms?

LAMADRID: 13:04

Texas, actually, planned for conditions that were worse than the ones that they saw. So to give you an idea, the top and peak of the system, is 75 gigs [gigawatts], and that happens in the summer, usually. So Texas is what we call a summer-peaking system and mostly because of air conditioning. The winter planning for this situation was actually set for 85 gigs. So actually, they plan for a much higher demand than even the highest that they have seen in the summer. But the way that they thought that this was going to be covered was mostly with, what we call, thermal capacity. And by thermal capacity, I'm talking about natural gas, oil, coal, things like that. So around 87% of those 85 gigs were going to be coming through-- they were going to be supplied by thermal generators. And around 50% were going to be coming from natural gas. Regarding wind, in the planning, those 85 gigs that Texas or ERCOT, which is the Electric Reliability Council of Texas, was planning for, it was only around 10% that was going to be coming from wind and around 1% from solar. So in reality, the amount that was planned, to start with, coming from wind and from renewable sources like solar — and wind has had a deep penetration the last decade. But ERCOT was not expecting that it was going to be very significant. It had received a lot of publicity. So the governor talked about that. There was actually, I think, the governor of neighboring states like Wyoming, were … talking about, "Well, we need some coal in order to address some of these issues."

LAMADRID: 14:55

I can tell you something from personal experience. So I moved to this area in 2012, and that was the year that Hurricane Sandy occurred. And after Hurricane Sandy, one of the things that happened is that a lot of these generators were requested... They were requested to have dual-fuel capability. So what does that mean? Well, let's say that you have a certain interruption in the supply from natural gas, which was what we saw in Texas, you could switch to another fuel and keep generating power. So that was something that was implemented in the U.S. blueprint. Texas had some level of dual-fuel capability. But to your question on how well did they fare, they were already some problems there. So in terms of the natural gas, that was one of the most affected. Actually in the Federal Regulatory Commission, which is their regulatory entity, and NERC, the North American Electric Reliability Corporation, are going to be doing an investigation about all the details. But as of now, around 20 gigs of natural gas, this is the best estimate as of now, of what's coming offline. So that is a very significant amount. Coal was offline. Wind, around four gigs of what they were expecting was offline. Nuclear was offline. So it was across the board. There was no denying there was a lack of supply in many of these resources. We'll see. Basically, this is going to be changing some of the practices. There may be some requirements, in terms of more weatherization of the supply. The pipelines were having issues. And in those cases, they ended up with a dry supply where they wouldn't be able to generate electricity because they don't have natural gas.

CROFT: 16:48

Now I know one of your research areas is the intersection of energy and electricity economics. So I'm hoping you can help me and our listeners understand something I know came as a shock to a lot of people as the news spread that in the weeks just before the winter storms hit, the price of wholesale electricity in Texas was just $20.79 per megawatt-hour. And in the wake of the grid's failure, the Electric Reliability Council of Texas, or ERCOT, which operates the state's power grid, raised the price to the cap astronomically high of $9,000 per megawatt-hour. And as a result, some of the fallout of that-- I know just this week, on Monday, the largest and oldest electrical cooperative in Texas, Brazos Electric Power Cooperative, filed for bankruptcy protection after it was hit with-- I believe it was a $2.1 billion invoice from ERCOT. And more bankruptcies are almost sure to follow. So how does the price of electricity go from $20 to $9,000 per megawatt-hour? And is there a way to prevent that in the future?

LAMADRID: 18:15

Yeah, that is a really relevant question at this point. So let me separate something here. So what happens in electricity is that we have a certain market that is, what we call, the wholesale market. So the wholesale market, with a lot of these-- let's say, for example, Brazos Electric that you were talking about, and some other entities, what we call, load -serving entities. So weirdly enough, electricity is one of those industries in which we [inaudible]. But these load serving entities, actually, they participate in that wholesale market. And those are the prices that actually are going to be skyrocketing. On the other hand, on the consumption side, a lot of the prices also are heavily regulated. So, for example, in the case of Texas, we have a Public Utility Commission, and the rates that many people are going to be seeing are going to be more average. They're going to be-- basically, depending on whatever was the average cost of provision over a period of time. The rates, whatever you're going to be paying for your electricity at home, is going to be reflective of that. So to give you a local example, my electricity provider is Met-Ed. So I live close to New Jersey. So there is no PPL. And the rate that I see there is around seven cents per kilowatt-hour. After I add all of the fixed costs, so there is going to be cost for infrastructure, distribution, and things like that. There's going to be-- it comes down to around 13 cents per kilowatt-hour. In the case-- and 13 cents per kilowatt-hour-- to put in context like what you were talking about, $9,000 per megawatt-hour; $9,000 per megawatt-hour is $9 per kilowatt-hour, okay? Here, we're talking about between 13 cents and $9. That is the difference that we were seeing in that situation. In the wholesale market-- so none-- most of the consumers are participating in the wholesale market. There is going to be an intermediary entity that is the one that does all of this buying, and in some cases actually builds the [inaudible].

LAMADRID: 20:23

So that entity, supposedly because it's not us-- but we have a lot of behavioral biases-- they should be hedging those kind of risks. The fact that we consumers are going to be seeing those kind of prices that may be down to the fact that in the case of Texas, actually, people can choose who's going to be their provider. And if you're going to be choosing a provider whose rates are going to be reflective of what is happening in the wholesale market, you're going to be seeing those impacts. So I don't know if in your case-- I have received promotions that they say, "Move to this other provide" Every state tends to have a different provider, which uses some rates that are going to be based on the average. But then some are going to be using these kind of more direct rates, and they are going to be automatically exposed to a lot of this price volatility. One of the first points that I mentioned at the very beginning is I do feel that a lot of this-- in many cases, demand, they should be much more exposed, or they should be more aware of what is happening because if you just have an average price, you don't know exactly what is happening in the overall system. And therefore, you cannot start internalizing those things. On the other hand, electricity is something that we need to provide. It's a utility. Everybody should be protected. So what we can think about is that it is possible to design mechanisms, hedging mechanisms or risk-coverage mechanisms that allow people that want to have those kind of signals to see them and still have some kind of circuit breaker that say, for example, avoids having very high penalties. So I do think that these kind of prices, the market was designed to have those kind of high prices because they participate in the wholesale market and use this as a signal of-- for example, in the long-term, the fact that I have such a high price means that me, as a supplier, should have all of the incentives to be available during those times. Now, a big debate that has been happening in Texas is that this scarcity pricing was not, very often during the last years-- during the last 10 years, the $9,000 was not being hit very often. And that led a lot of the suppliers to, for example, defer or avoid taking some investments that would have been-- for example, some winterization would have been possible, and maybe some of these suppliers could be available and could have taken advantage of those high prices.

LAMADRID: 23:02

On the demand side, a lot of these entities, they should have been covered. I think that that's one of the-- as part of the design of the market, we always think that the load serving entities should have hedged some of these risks, and they should be passing it directly to the consumer. Consumers are not going to be-- most of the people-- I do this for a living, but most people are not going to be seeing, all the time, what the prices are. But it is possible to design it in such a way that consumers are going to be protected and they still receive some of this information. So to give you an example, in general, the way that we see these kind of signals is very coarse. We receive a monthly bill and then we see, "Oh, generally, my electricity bill has spiked up. But I don't know exactly from which day does it correspond?" So if I had some of that information, I would be able to, for example, adjust my thermostat better or start doing other activities like try to, for example, use electricity at times that are not peak; avoid doing my laundry now and doing it later. At the wholesale level, I think that those prices are going to be remaining. Now, this is completely conjecture and my crystal ball is as cloudy as anybody else's, but we'll see that-- I do think that there is still probably going to be this kind of a scarcity pricing. There may be some pressure in order to have entities participating in these markets to be more hedge. This is a little bit reminiscent of what happened 10 years ago, a little over, with the financial crisis. In many cases, the banks that were suffering when we were in the last financial crisis, we were expecting that they were going to be hedged. But in certain situations, actually, this was passed down to the consumers. So we'll see if there's going to be more discussion about some ways to cover these kind of extreme events; inform, better, consumers, taking into account, in many of the instances, the information comes down into the footnotes of the contract into the small letter. People, sometimes are inattentive to whatever they're going to be signing. So we really need to put some protections in there and make sure that people-- particularly right now, there's a big concern about environmental justice, people being able to have affordable electricity. Which in certain cases, having low-average prices means that you're going to be pushing suppliers who maybe don't invest in these kind of capacity investments that are relatively expensive.

CROFT: 25:35

Now, it sounds like-- and I had mentioned the ARPA-E US Department of Energy Grant that the team you're part of, at the University's Institute for Cyber Physical Infrastructure and Energy got that is to develop a framework and platform for asset and system risk management, some of the things you've been talking about, that could be incorporated into the current electricity system operations to improve economic efficiency. And clearly, we're seeing [laughter] the need for more economic efficiency in the system. So could you talk just a little about the grant and what it is that-- who you're working with at the university and what it is that you're hoping to develop?

LAMADRID: 26:23

Yeah. So thanks for that question. Overall, as you said, I think that this grant was coming out of the need to improve the risk management in the system. Overall, the system, it is amazing how well has it held, in general, given the fact that it has changed a lot during the last 20 years. So when these markets were originally developed, they were not thinking that we were going to be having that much renewable energy. So because of that, a lot of the design features are based on suppliers that we can control, right? But the moment that we start using much more renewable energy-- as you know, we're going to be producing with wind energy-- nobody has to pay for the wind. So there's no cost associated to that. But we don't know whether it is going to be as windy as our models predicted. So because of that, we ended up in a situation in which we're using market designs that were based on more controllable generation, but our portfolio generation has changed significantly. So this is a collaborative effort with our colleagues in electrical engineering. So my two colleagues are Shalinee Kishore (Iacocca Chair Professor of electrical and computer engineering and Associate Director, Institute for Cyber Physical Infrastructure & Energy) and Parv Venkitasubramaniam (associate professor of electrical and computer engineering). And this is a multi-institutional effort. So besides Lehigh, we have people from MIT, and we have two national labs, which are part of the Department of Energy. So the national labs are Argonne National Lab and Lawrence Livermore. And our objective is exactly that, is to start coming up with better ways to handle the risks, using tools from finance, using tools from banking that allow to hedge these kinds of risk. Now, overall, the fact that we're going to be using much more renewable energy sources, which are intermittent, means that we're going to be dealing with overall risk every single day. In normal operation, even without these kind of extreme events, … day to day, we're going to be dealing with much more intermittency.

LAMADRID: 28:28

So we're going to be looking at the mechanisms in order to handle the risks during those normal conditions. And when I say, "normal," quote/unquote, in the sense that this is something that is going to be closer to the center of the probability distribution. But then, also, we want to have risk management for those daily events like the ones that are going to be rarer that may be happening once every 10 years or every 20 years. The methodologies, in certain cases, could be similar. We adapt them in order to make sure that actually they're reflective of the overall operation of the system. But I think there's a lot that we can learn over here. I typically say that whenever we're thinking about these large infrastructure systems, we're thinking about three parts. One is economics, like all of these market designs, "How do we adapt them to the changing conditions, changing portfolios, and changing priorities in order to decarbonize and do a transition to a low-carbon economy?" Second is technological. There may be some technological fixes, more availability of storage, for example, more HVDC lines, like high-voltage DC lines that allow us to interconnect. There may be other forms of storage, for example, if you have a surplus of renewable energy in the middle of the night when nobody's using it, you're going to start producing other kind of energy storage forms, like, for example, producing hydrogen and storing it, or using thermal storage and then using that for air conditioning services and for heating services. And the last thing, besides the technology is going to be all of these institutional arrangements. So like, "How are we going to be dealing with the risks?" I mentioned to you that Texas is fiercely independent, and a lot of the institutions that have developed are representative of those kind of preferences, like social preferences.

LAMADRID: 30:29 So in that sense, we should see if there is maybe some regulation that is going to be entering. I've seen, lately, a lot of push for, for example, more winterization like weatherization in general. There's wind farms that are operating in much worse environments than the ones that we have here, that we saw in Texas, in particular. There's going to be a difficulty in the sense that there's big swings that happen there in temperature in a very short period of time. So there's still going to be some regulation part and some technological part. But that's part of what we're working on, that you try to bring tools that could be key, having a real impact in the short-term in terms of this risk-management in electricity systems, taking into account those three aspects. And like the fourth leg of this stool, making sure that there's affordability. There is no reason why we cannot design systems of these mechanisms in order to make sure that actually we, for example, cover populations that we want, that we consider that they need some protections or that we provide people some choice in order to decide, "Okay, if you enter into these kind of contracts, how are you going to be hedged?" Because, at some point, there may be a little bit of moral hazard in the sense that some people may sign up for some contracts that they don't fully understand, and may expect to be bailed out, or some people may actually not even expect to be bailed out, but they never even foresee this kind of situation. So we need to start coming up with better ways in passing this information through, making sure that people understand what they're signing up for, and that entities like this-- this is not a failure of households. This is actually a failure of the design at the wholesale level. These load serving entities, they should have been better protected. Sometimes because it's a utility, it gets passed to the government. So there you go, with the systemic risk that we're going to be facing. But that's part of what we are trying to solve here.

CROFT: 32:39 Great. And we look forward to checking back with you as this grant proceeds. It's been fascinating. And I thank you so much for being here with us on iILUminate today.

LAMADRID: 32:54 Thank you so much. I really enjoyed it.

CROFT: 32:56 Dr. Lamadrid, also is a member of the Integrated Networks for Electricity Research Cluster and the Power from Oceans, Rivers and Tides or PORT Laboratory at Lehigh. As I mentioned before, his interests lie at the intersections of energy and electricity economics, as well as complex dynamic systems and mechanism design. This podcast is brought to you by iILUminate, the Lehigh Business blog. To hear more podcasts featuring Lehigh Business thought leaders, please visit us at business.lehigh.edu/news. And don't forget to follow us on Twitter, @lehighbusiness. I'm Jack Croft, host of the iILUminate podcast. Thanks for listening.