College of Business
LEHIGH UNIVERSITY

iILUminate Blog Transcript: Alberto Lamadrid on Data Centers

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ANNOUNCER: 00:02	[music] This podcast is brought to you by iILUminate, the Lehigh Business blog. To learn more, please visit us at Business.Lehigh.edu/news.
STEPHANIE VETO: 00:13	Welcome to iILUminate, the podcast for Lehigh University's College of Business. I'm your host, Stephanie Veto. Alberto Lamadrid is with us to talk about data centers and his work with ACES, the Center for Community Advancing Electrification Solutions. Alberto is a professor in the Economics Department, part of the Integrated Networks for Electricity Research Cluster and the Institute for Cyber Physical Infrastructure and Energy. Hi, Alberto. Welcome to the show.
ALBERTO LAMADRID: 00:41	Thank you. Nice to meet you, Stephanie.
VETO: 00:43	You too. So you study energy systems and electricity economics. What's driving the growth of data centers right now?
LAMADRID: 00:52	One of the main drivers is the need that we have for artificial intelligence. And this is a need that is happening on both the supply side and the demand side. So on the supply side, there's a number of companies that actually they've been growing in terms of capitalization, and they are trying to come up with new and innovative models. And they're going to be using increasing amounts of power, right? So in order for you to answer a query, I assume that every listener to the podcast has probably used ChatGPT or have used Claude or any of these kind of artificial intelligence systems. Part of it is, how do you train that system? And training that system is very energy-intensive. On the other hand, we have the demand side. All of us are using artificial intelligence. So I am a faculty in an economics department. Our students are learning how to use artificial intelligence. Some of them are going to be using it for their homework, for doing research. Some of them are going to be using it for personal questions, right? So a lot of people are going to be using for planning their next vacation or whatever. So you're going to be having increases on the supply side and on the demand side. And all of that goes to increase the amount of electricity that you're going to be using because all of these systems are going to be running on that infrastructure. You need power in order to start giving the calculations required for all of these calculations and processing that artificial intelligence requires.
VETO: 02:21	How did you get interested in studying the economics of electricity?
LAMADRID: 02:26	My dirty little secret is that, actually, I was originally an electrical engineer. So I was trained as an engineer initially, and I was finishing at the end of the '90s, early 2000s. And that was a very changing time. It was a lot of changes going on in the world. So I'm from Colombia, and during that time, we were actually doing a restructuring of the electricity market. Tempting was happening in many other countries. So same thing was happening here in the US. You may remember 26 years ago was the California electricity crisis. So we were learning a lot at that point. At that point, I was a student, and I was interested in understanding better, the motives, the incentives, the reasons why people are going to be behaving in one way or the other. Right. I had

the technical training, and then I decided to go into more the economics. So it's an intersection of the two disciplines.

VETO: 03:22 And what makes AI and cloud computing different in terms of energy demand? Why do we need these huge facilities?

LAMADRID: 03:31 First is these are completely new models. And these new models, they are trained in what they are called AI data centers. These AI data centers are not your grandmother's data centers. We've been using data centers for a very long time. So actually, at Lehigh, for example, we do have a data center that is used to process our local needs, right? So people are going to be using for putting the homework. There is a website that is called core site that you're going to be using all of that information, and you need local processing power. These new data centers or AI data centers are completely different in the sense that you need huge facilities. And typically, the way that they're measured, before you can have a data center that was basically a couple of servers that are going to be providing local services. So they're going to be, for example, for a company if they need to process their local payroll or whatever it is. These AI data centers, on the other hand, they're measuring football fields. They're going to be having racks and racks of servers that are going to be used in order to process. I would like to start doing--

LAMADRID: 04:39 There's two main things that the artificial intelligence requires. One is the training of the model that is going to be ingesting massive amounts of data in order to come up with a model that is actually going to be useful. And the other part is called inference. So for the training, there is a lot of electricity use right now. And you need large data centers to do it. Some of them are going to be doing process in parallel. Some of them are going to be waiting for some of the processes to end. But that is different from the previous way that we were doing processing, right? So I think that the previous revolution that is similar to this is when we were expanding, for example, internet services. A Google search is much smaller than, for example, a Gemini query that you're going to be asking. So in that sense, this is a fundamental change in terms of the amount of electricity and the facilities required in order to perform them.

VETO: 05:34 What are some of the environmental concerns about these big data centers?

LAMADRID: 05:41 There's a couple of them. So first of all, because it's computing processing power, you're going to be needing electricity. You need to power those data centers. There's going to be direct and indirect use of water, right? So you need to have water use because actually, every time that you're going to be producing a lot of calculation, you need to cool down the computers that are going to be doing these calculations. So there's going to be direct water use in the data center. On the other hand, because they need electricity, there's indirect water use. That is, you are going to be using all of that electricity. And the generating plants that are going to be producing that electricity, they need to be cooled down, right? So there's going to be that kind of indirect water use. We produce electricity talking about Pennsylvania. So over here, we are part of a market. So there is not a central authority that owns the plants and then decides to dispatch something. It is a restructured system. And all of those plants here, we use a lot of natural gas. And this is a legacy of our-- for example, we are very lucky to have a number of resources, particularly shell gas.

LAMADRID: 06:48

So there's going to be pollution that is going to be coming from-- if you're going to be producing electricity using natural gas, even though it's much more benign in terms of the amount of emissions than other, for example, forms of producing electricity like coal, it still has emissions. So there's going to be those kind of concerns in terms of what is going to be the emissions being produced at the production of electricity. And there is emissions or pollution that is actually coming from the noise, right? So one thing that happens with a lot of these data centers is that they have uninterrupted power supply next to the data center. That an uninterrupted power supply typically is diesel-powered, right? So you never use it, or you use it very rarely, because here we have a very reliable electricity system. So you're going to be mostly buying your electricity from the network, the grid. But every month or every couple of weeks, you're going to be testing that this backup equipment is actually working. And then you're going to be putting to run those diesel generators. So there's going to be the emissions that are going to be produced during that period. And there's going to be the noise that they're going to be producing, right? So there's going to be some noise pollution. And that can be an environmental concern as well. Those are going to be probably like the main environmental reasons that I'm going to be talking about.

LAMADRID: 08:12

There's another way in which actually you can think about this. So I've been talking about pollution that happens in the air, right? So because of the production of electricity, there's going to be water use. They're going to be using a lot of land because these are very large data centers. And then you're going to be occupying football fields. And what that means is that you may have, for example, a forest. And then you're going to be removing the trees that are going to be over there. In certain cases, there's not going to be a lot of absorption of, for example, emissions, local pollutants or things like that. So there's going to be that consequence of having impermeable surfaces or things that are not going to be as good in order to be cooled down, right? So that you have a little bit of urban heat island effect in this case because of the data center.

VETO: 09:03

What are some misconceptions the public has about data centers?

LAMADRID: 09:07

I think that a lot of people think that a data center is like a factory that is going to be like the last thing. So Lehigh University is in the Lehigh Valley. The last similar wave that we had was when a lot of the warehouses came. And we were expecting-- at the very beginning, I think it took the community by surprise. And then all of a sudden, we saw all of these big trucks moving along our highways and creating congestion. In those kind of factories, there's a lot of automation, but there's also a lot of workers. I think that AI data centers, the number of jobs that they produce in the long run is much more limited. Mostly it's huge parts of racks and racks of servers. So in that sense, they're not going to be having that many jobs as compared to the last wave of what we had in this area. And we may have some employment effects. But these are going to be mostly driven during the construction stage. And I think that the other one is-- sometimes we don't think about what you were asking me just before, like what are the byproducts of the data centers? In some cases, so data centers come in-- lately, they're much larger. Some of these data centers that are popping up in Louisiana are some of the largest in the world. Depending where they are, they can have very different effects on the community, right? So in certain cases, they're going to be using much more electricity that is coming up from solar generation or from

wind generation. In other areas, they're going to be using much more natural gas. So it's not all data centers are the same, right? They're going to be having very different effects. And sometimes when people start getting their information, they may get much worse or much better information according to whatever are the sources that they're using. So I think that that's probably one of the misconceptions is that there's going to be some general effects. But not all of the data centers are going to be identical. There's going to be a lot of particular issues according to the area.

VETO: 11:07

Yeah, that makes sense. One data center experience is different than another data center experience. And, yeah, it might affect a community a little bit different. Can you talk about the work being done by Lehigh Energy initiatives like ACES?

LAMADRID: 11:23

Absolutely. So at Lehigh, we have a new center. It's called the Center for Advancing Community Electrification Solutions, ACES. And one of the things that we're interested in is in understanding all of this electrification. Electrification is happening in different realms, right? So data centers, it's new buildings that are using a lot of electricity. So that is one. And generally, not only data centers, other buildings are geared towards using more electricity. For example, traditionally, some houses in the northeast of the US, they were using fuel oil, or they were using gas in order to be heat up. You can start using electricity with heat pumps. So ACES is also doing understanding of that kind of using electricity for heating and for cooling. It's interesting about electrification of transportation, right? So if we're going to be moving towards more individual transportation using, for example, electric cars and the interactions with water, right? So this is two very codependent systems. So you need electricity in order to run water systems, and you need water in order to start cooling down electricity systems. So ACES does all of this. This focus on data centers is something because in Pennsylvania, we do see a large development happening there. So we're interested about understanding the consequences from the technical point of view. For example, finding ways to cool them better, start reducing water use, start, for example, being more effective in terms of the amount of total energy in versus amount of computation out, the power usage effectiveness and the water usage effectiveness. But also in general, because of the environmental consequences, social consequences, and economic consequences that this may have.

VETO: 13:11

You recently participated in a forum with PBS39. What do you think stood out to you from the community concerns?

LAMADRID: 13:20

I do think that initially, a lot of people were, I wouldn't say that they were negative or positive. I think that in many cases, people are a little bit wary of the unknown because the information is not sometimes very easily passed. I think that there's a lot of non-transparency. Sometimes it seems that the community feels that there's information being withheld. And I mentioned regarding the warehouses, a couple of the participants in the panel, they were telling me that before, the community was relatively open and they didn't understand a lot of the consequences of new developments. And now they are maybe overprepared. And I don't say it in a positive or negative manner. In many instances, they try to do their homework in advance, which is wonderful. There's a lot of misinformation out there. So you have to be careful about what do you find sometimes as we were discussing, not every data center is going to be the same. So it's good to ask the right questions, but maybe this is a little bit of the pendulum in which people say, well, in this occasion, we don't

want to be caught by surprise again. So it's a good thing. I think the community should be getting information and questions about what is happening in there. But I think that there's still that lack of transparency that is felt in certain communities.

VETO: 14:38

Can we talk about why Pennsylvania is becoming a hotspot for data center development? I mean, the land isn't even flat. It's rocky and mountainous and forests and it doesn't seem like an ideal location for a data center.

LAMADRID: 14:53

Yeah, I agree with you. I think the geography over here, it's not exactly flat, right? So there's a number of changes. On the other hand, Pennsylvania has a couple of interesting and good features if you're going to be having a data center. For one, we do have a lot of energy, right? So given the Shale Gas Revolution, for us, historically, Pennsylvania has been an exporter of electricity. I mentioned you that actually there is not a single entity that manages the electricity in Pennsylvania at the wholesale level. We have something that is called PJM. And PJM is the largest electricity market in the world. It manages Pennsylvania. It manages Jersey, Maryland. So that's what the PJM used to stand for. But it manages all the way to Chicago, to the West, and it manages, for example, parts of North Carolina, Ohio, and so on. Generally, Pennsylvania has been an exporter of electricity. So we have good conditions. Electricity has been cheap for a number of years historically. We have good broadband connectivity, and for you to start putting a new data center, you need to have some of that connectivity. It's not that you're going to be just doing the computation. You need to submit the results to whoever is querying them. So you need to have good infrastructure of communications, and you need to have good water. And generally, Pennsylvania has good water sources. Having the intersection of those three things, power, communications, and water is relatively rare. We are close to one of the main hubs of computation that is actually in Virginia. So that may be another reason, right? Geographically, Virginia is also part of PJM. So there may be some kind of geographical reasons why we're going to be having that facility or the affinities to start developing data centers.

VETO: 16:45

Not to get too into the weeds. You mentioned that Pennsylvania is an exporter of energy. And can you describe how energy is exported and how Pennsylvania makes money off of that?

LAMADRID: 17:02

Yes. So the way that it works--I'm going to be talking about electricity first, and then I'll move into energy in general. So in terms of electricity, you produce electricity in a power generation plant. You're going to be-- for example, let's say that you're going to be using natural gas. So you produce the electricity over here, you are going to be transmitting it to whatever the consumption centers are, and you get paid for selling that electricity, right? So there is going to be a revenue stream for the owners of that generation plant, right? It could be an independent power producer. It could be a large conglomerate. So that is the people that are going to be getting some of that revenue. From the energy point of view, we're going to be extracting natural gas, and that can be used for chemical processes, for industrial processes, for electricity production, and all of those area, right? So those are going to be two revenue streams. One from the energy side, more kind of like thinking about, for example, the natural gas as a raw material. The other one is from the electricity. The money we get whenever we're going to be selling those products, right?

LAMADRID: 18:09

So for example, in electricity, you're going to be selling that into a wholesale market. The wholesale market-- the way that the electricity works is that PJM is actually an administrative boundary. But electrons don't know those administrative boundaries they're going to be flowing. So there's going to be an independent system operator that controls, for example, what is going to be the interface with, let's say, New York, right? So New York is in another system, administratively speaking, but it's in the same electrical network, right? So you can be exporting-- actually, as a producer in Pennsylvania of electricity, you could be exporting to New York. You could be exporting to, for example, down to North Carolina, the Duke Energy system. There's going to be some limited interfaces, right? And they're going to be managed by the independent system operator. But that's a way in which actually, similar to-- to make an analogy, even though I don't want to stretch it too much. It's like almost any other product, right? The main difference is that this other product is transfer is electrons that you're going to be passing through transmission lines. And with natural gas, you're going to be passing these molecules through a pipeline, right, or through different other ways. Sometimes we're even going to be exporting through liquefied natural gas.

VETO: 19:25

I love that. That actually really helps because I feel like I need to have a physical idea of what it is. I can't fathom in my little brain how we are exporting energy. It's incredible. You see the windmills and the solar farms and all that, I get it. But to actually break it down is so fascinating. So it's very interesting to hear and talk about. I want to talk about a local example, and full disclosure, I'm from this area, so I just need to lay that out for this. But there's an area outside of the Lehigh Valley. It's northeastern Pennsylvania, and the town is called Archbald, Pennsylvania. It's a very small town, and it has a lot of land and mountains surrounding it. They're seeing multiple large-scale data center proposals happening right now. And we talked about why it's happening in Pennsylvania and all that. But we're seeing, like you read in the news, a lot of pushback from the community happening in-- it's happening in real time. They've got forums, and they're showing up to council meetings, and they're really pushing back on a lot of stuff. How do you think that data center companies and communities can better communicate with each other?

LAMADRID: 20:53

Yeah, actually, I do think that there's different actors that actually can play on that. I do feel that in certain cases, the case that you're talking about, Archbald, is a fascinating one because I do feel that this lack of transparency between the different parties is sometimes an inhibitor. It makes it more difficult to get to an agreement, right? So I don't think that the community wants to stop, as any project, for the sake of it. Members of the community may see benefits maybe on the jobs, right? So there's going to be direct and indirect jobs that get created with a new data center. There's going to be some revenue that the municipalities can use. But on the other hand, sometimes they get caught by surprise about feeling that nothing was communicated properly. And developers, generally speaking, even though they tend to be secretive, they need to have a license to operate in a certain community. You cannot be adversarial with any community because you don't want to be kind of like the sword in the middle of some-- next to a school and be a bad neighbor. So I think that it is in the best interest of both parties to actually communicate. I do think that maybe that lack of transparency and the fact that sometimes, for example, a developer for a data center just goes ahead with certain plans and doesn't

communicate clearly to the community, that creates that sense of like there's something going of which me as a member of the community and I'm getting informed. So it always helps to facilitate that to make sure that there's going to be these kind of town halls where people raise questions. I mentioned before, there's a lot of misinformation out there. It's good that people actually start doing their homework, go to these kind of town halls and start asking those kind of questions.

LAMADRID: 22:44

I do feel that we as a university also have a role to play, right? So we live in these communities. We are not developing data centers, but we can actually pass information that can help people in an unbiased manner, evaluate the trade-offs. So there's going to be benefits associated to these activities. There's going to be some negative sites in certain areas. And that is true from almost any economic activity. So we always need to see whether the benefit is going to be larger than the cost, but it's rare that we see activities that have zero cost, right? But then we learn how to deal with those costs. So for example, I love to go to the beach. To go to the beach, you have to suffer the cost of congestion, being in a traffic jam for a while, right? So they're like, in that sense, we need to understand all of those kind of externalities. That's the economic jargon way. There's a number of other externalities that we're going to be facing whenever we have a new large participant in the community that is going to be using a lot of electricity, water, is going to be using a lot of land. So it's a matter of getting that information and understanding what is going to be the benefits and the costs associated to the operation.

VETO: 23:55

I think hearing examples of data centers going up and hearing about communities pushing back or asking questions, I think there's going to be a lot of things learned from it, what not to do and what to do. I mean, even again, to use the Archibald example, there's aerial shots of where the land is being developed for these data centers and it is right against people's backyards. There's like a yard and then the land is in there.

LAMADRID: 24:32

The very center.

VETO: 24:33

Yeah, that's where it's going to be. And it's just, it's shocking to see. And you can see that concern alone is valid. And, I mean, these are people's homes where they live. And so it raises a lot of questions, but also I think a lot of things can be learned about this. And this goes into my next question. What do you think responsible data center development can look like?

LAMADRID: 25:02

I think that the developers, first of all, should be making sure that the community is aware of what is going to be happening. So I do think that there is a role for local regulation as well. So in general, we want regulation whenever there's going to be, for example, market power. If there's going to be an entity that has a lot of power, in terms of the transaction that they can negotiate different things or terms, then you want to have some kind of role for like local governments or some other institutions that are going to be helping arbitrate or regulate some of that kind of activity. And when I say regulate, it's not completely from the regulatory point of view, but it's just to facilitate the dialogue. I do feel that as long as the developers are going to be passing some of this information and there's going to be some local capacity in order to understand what the applications are, that can help. But the developers should clearly pass information. Be transparent. The local communities, for example, who's

going to be creating land ordinances, they should request for some of the conditions in terms of like, for example, the electricity use, the water use.

LAMADRID: 26:15

One thing that has been happening, and this is the area that I do most research about that is about electricity markets, is that for the last 20 years, we have a relatively flat electricity demand. So as you were asking at the beginning of the podcast, I think that this kind of growth in terms of electricity demand is relatively unseen. And because of that, we haven't flexed our muscles in a while in order to understand what happens whenever all of us are having much more electricity use, right? So like we need to get used in order to get better forecast. And that is going to be having implications in the short run. If you don't have-- this is like with any other market. If you have a lot of demand and there's not enough supply, prices are going to be going up. Right? So I think that generally trying to cover that fact is probably going to be creating a mistrust in terms of the developers. It is a normal effect, right? And what you have to really start dealing with is like, okay, we see that in the short run, there's going to be a scarcity of supply or there's going to be some kind of constraints. We are going to be the long-term effects in order to, for example, mitigate those electricity price increases. So I think that that's part of the activity that developers should be doing. And part of the questions that the community should be asking.

VETO: 27:38

And as far as the infrastructure that we have now, is it true that the energy demands can't keep up or the infrastructure can't keep up with the energy demands because of AI growing?

LAMADRID: 27:56

So there's a little bit of truth to that, right? So I think that if all of the data centers were going to be using pure electricity from the grid, we're going to be constrained. And sometimes-- you may be familiar with this. There's this expression that is not in my backyard that you mentioned about having the data center next to it. Communities, generally speaking, they are apprehensive to see infrastructure development of any type, right? So some people prefer to have the amenities of having a forest behind or things like that. So if data centers were going to be using electricity only from the grid, we're going to be a little bit constrained. One tendency that we have seen lately is that many of these data centers, they're bringing their own generation. So the term or the expression is big YOG. So it's called bring your own generation. And sometimes what that means is that the data center is going to be almost like a city. They are going to be having a lot of electricity that is going to be used for local purposes only. So it's going to be used in order to do their computation. And they may have a limited use of the electricity from the grid. So that alleviates some of that congestion that you're asking about, right? So there's going to be some limits in the infrastructure, but then if you bring your own generation, you're not going to be pushing that much. You're still going to be using water, right? So they're still going to be using land. So all of those other things are still going to be occurring. But it may mitigate that problem with the electricity demand. Infrastructure is going to be pushed a little bit. I wouldn't say that it's going to be breaking it down. It depends on the particular data center, but some of them are going to be having enough generation that is going to be helping with the management.

VETO: 29:45

Can you talk a little about the financial side of these data centers, the investment, the revenue, any tax benefit possibilities when it comes to the community or even the data center owners? What's the financial side of all this?

LAMADRID: 30:02

Yeah, that's an interesting side in the sense that we mentioned before, for example, OpenAI and like all of these companies that actually have been growing. These companies have seen unprecedented growth. They have grown faster than many of the previous generation companies like Google and things like that. So in that sense, there's a lot of funding that is coming from private equity. There's a lot of funding. In many cases, these data center developers, they have very deep pockets. It's not that they're financially constrained because there's a lot of people that they're betting. Imagine that actually-- and many people are already using the product of these data centers, which is basically an agent as almost an assistant, right? So it can increase the productivity of people. It can increase, like for example, the way in which actually I'm going to be producing my work and how is it going to be making me-- helping me become a more effective worker. So a lot of investors are willing to make the bet that there are going to be gains eventually. The company, some of them, they're not making a lot of money as of now, right? So it's almost a betting to the future in terms of like, oh, I see that the next generation of plot is going to be helping me find, for example, cybersecurity flaws that before it took me many, many years. But there's still-- we'll see how long does it take for some of these companies to start making some money. Basically what we see is that there's a lot of liquidity. There's a lot of optimism in terms of like the potential. But it's not that this is a fully funded operation. It's running on the expectations that there's going to be great things coming out of it.

VETO: 31:48

Finally, what do you think the US energy landscape is going to look like in the next 10 years?

LAMADRID: 31:55

Generally speaking, and this is actually related to the question that you were asking with ASUS. I think that we're going to continue this tendency of electrifying more and more, right? So we're going to be using more electricity, not only for data centers, but like for transportation, for like our houses, for things like that. They're going to be more demand also from the industry side, from manufacturing. So we are reshoring some manufacturing capacity. So that may create some demand for more electricity production and infrastructure. And I would say that to look from the entrepreneurial point of view, I think that this is a good opportunity for investment. It's a good opportunity to start rethinking our markets. So I think that our markets have served us relatively well for the moment that they were designed. They were designed for a very different moment in history. And now it's a good time to start thinking, is the current designing markets appropriate for what is coming into the future? We have to make sure that the electricity that we're going to be using is reliable, is going to be affordable. So we may have a little bit of pressure, but it's a good call for researchers, for people in industry to start thinking, these are new improvements that we can have. So yeah, the energy landscape, probably like right now, we see a lot of innovation and pressures. But I think that in the next 10 years, probably we're going to be seeing more innovation and more changes in terms of market design.

VETO: 33:29

Alberto, thank you so much for being on the show. It was great talking with you.

LAMADRID: 33:33

My pleasure, Stephanie. Thank you so much.

VETO: 33:35

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