Research @ Citi Episode 82: Watts the Problem?
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Transcript:

Rob Rowe (0:00)

Welcome to our Research @ Citi podcast. I'm Rob Rowe, the current acting Global Head of Research. And with me on the podcast today is Tony Yuen.

Two years ago, we thought that the power grid was under enormous strain because of rising demand and supply, both on the data-center side and renewables side. How has that situation changed since then? Now we have even more demand due to data centers. We have even more renewables. We have EVs.

[*See our related note:* Must C: Overcoming Gridlock 2.0]

Tony Yuen (0:34)

So the power grid certainly is really important because our lives really right now revolve around electricity. But then the power-supply side tend to come from places that are really far away. And that's why the power grid is enormous, but it's also aging and it needs upgrades.

But at the same time, power demand — as you talked about, the data-center side has been rising very quickly. Over the last couple of years, the estimates for data-center power demand have just gone up even more because there are even more use cases and then more greater expansion.

But then there is also the broader narrative and megatrend going forward as well, which also need the grid to expand. So it's not just within the U.S., but also globally, because this issue is actually exacerbated by what happened in the conflict in the Middle East, because some of the countries right now are rethinking the whole notion of energy security. And these countries are really thinking about energy sources for power generation that want to be domestic. And also you can see the electric-vehicle sales have gone up as well, because they also want fuel that power these vehicles that would be domestic, right? But all of these require more power grid and all that. And the challenge is large and it's real.

So the IEA just published a report earlier this year, basically summed it up really nicely. It says that roughly 2,500 gigawatts of renewables, storage, and large demand projects, such as data centers, are stalled because of the grid problem. So to give a sense of scale, a city with a million people generally uses one to two gigawatts of power. We're talking about 2,500 gigawatts of renewable storage and large demand projects like data centers are stalled. So what that means is that we are talking about the grid, as good as it is over the last 100 years in providing electricity to us, it's now still a major issue at this point.

Rob Rowe (2:35)

And beyond those power-supply challenges, what are other constraints do you think you would anticipate facing?

Tony Yuen (2:41)

So I think what happens is that right now, given that expanding/improving the grid proved to be rather difficult because of regulatory and labor constraints and others, that's why, on the one hand, there's a lot of demand for electrical equipment just to improve the grid to the extent possible, but then also bring forward the use of more on-site generation as well.

But then if you just step back, why is it so difficult to expand a grid? Well, if you look at the regulatory framework, it is basically necessary because you want to take care of the stakeholders, the people who are living there, and then environmental issues — you certainly don't want the power line right in your backyard, right? Hence the NIMBY part. But this is real, right?

And then also the other side is that, for example, in the U.S., the labor issue is really big. So the BLS, Bureau of Labor Statistics, Department of Labor, essentially it's saying that there are shortages of labor, professional trade labor by roughly about 220,000 workers in critical industries like construction, HVAC, electrical, and many of them basically you require to build data centers, but also required by utilities, renewables, EV charging. So there's a lot of overlap.

But then these skilled tradespeople, they don't suddenly come out and can call upon them, and you cannot train them and then get them ready within a month or what-not. And basically BLS expect that to be a shortage well into the 2030s. And so then not only is the labor being an obstacle at this point to further expanding a lot of the grid, but also regulatory, which we talked about.

But then there’s something interesting about the kind of demand that data centers draw from in terms of electricity. Because it's not just that the demand for electricity is big. It's just that they're highly volatile. So let's say a training modediscul suddenly needs to ramp up. This actually demands a lot more electricity and then they can ramp up and down very quickly, big swings.

It's almost like the demand side of renewables. Because if you think about wind generation, solar generation, if there's no wind at the cloud, then basically generations just come off. And so what that means, the grid also needs to accommodate that not just volume aspect, but also volatility of these power generation. So that means that the situation becomes much more complicated than just delivering power.

Rob Rowe (5:22)

That's interesting. And so given the rapid growth of data centers, and I guess we would say demand, what's the current landscape for critical power equipment? And what's your outlook for its evolution in 2030?

Tony Yuen (5:35)

So there's actually definitely significant opportunities. If you look at the U.S. data-center electrical-equipment market alone, it's projected to grow from roughly about $20 billion in 2025 to roughly about $65 billion by 2030. And then to get a more broad scope, the global transformer market will likely expand from roughly about $60 billion in 2024 to $93 billion by 2030, somewhere around there. This surge in demand for these electrical-equipment, by fuel, by data centers, utilities, renewables, really put a big strain on the infrastructure and manufacturing. So that's why you have a lot of bottlenecks within the components of fuel of the grid.

So the grid is not just power lines — in fact, there's a lot of overlap in terms of what the data centers want in terms of power equipment as well as the renewables side. So definitely there's a lot of demand for large power transformers, a lot of generated step-by transformers, high-voltage switch gear, medium-voltage switch gear, and so that's why recently our colleague talked about solid-state transformers being something new as well. There's actually a lot of overlap.

And that's why the market is getting quite big. But also because of such strong demand: The wait time for this equipment basically ranges from something like 18 months to four years. And that's why some of the developers of data centers or renewables, particularly data centers, are moving towards more self-generation. And that's why the situation on the grid has been evolving into a different kind of landscape.

Rob Rowe (7:15)

That brings up another development as well, because you still have this enormous demand, but the supply will be coming on slowly as a result of these items you're mentioning. But you have a phrase called BYOG, which I think is hilarious, it's great: Bring Your Own Generation. This is obviously a manifestation of what's going on. How do you see that connecting to the grid? It is a huge hurdle, because of infrastructure and transformer limitations. But what's the most realistic solution for data centers right now, especially when you think about BYOG?

Tony Yuen (8:00)

I think definitely we can look at what the hyperscalers have done, because it's an example to see the evolution and how they see this market to get the power to data centers. So initially, if you look at before, you can see that they want to co-locate the data center at existing power plants, right? So there were some deals between hyperscalers and the utilities, right? And that's why some of the revival of nuclear power plants. But there are very few of them. And so basically, they are done with that co-location with some of the existing power plants.

And then, of course, there's co-investment with PPA, which is a power purchase agreement, typically renewables. But then one thing about renewables is that typically you need a big land mass, your footprint. And so your data center either is literally where the solar farm, wind farm would be, or you have to be far away. That means that you need a grid. And we just talked about expanding the grid is not easy, that's why the solution is Bring Your Own Generation. Literally, you build a data center and have the generation right next to it so that you can serve power. And that generation can become bigger and bigger.

And some of the solutions that people are using more and more would be natural-gas turbines, the combined-cycle or single-cycle, which is the typical power plants that we use. And there is something called the reciprocating engine, or recip engine. There's the four-stroke engine as well. There is the aeroderivative turbine, which is basically jet and converted using jet fuel into natural gas. There's solid oxide fuel cells also used as natural gas. Diesel backup, and all that, right? Plus, of course, you still have renewables and batteries. And so, because they couldn't really solve the grid problem very quickly, that's why they moved towards self-generation.

But this actually gives us an example of, show us a deeper structural element involved. Why do we have a big power grid? It's that historically, the longstanding key advantages of the current centralized power system — in the industry it's called a bulk power system, BPS — with large transmission network is that power generation is supposed to be more cost-efficient when you have big power plants.

But big power plants tend to be located far away from demand centers. So that means that you need a grid to do that, right? But if the grid now becomes a bottleneck, and if distributed generation that we are seeing in terms of these BYOG, Bring Your Own Generation with the gas turbines, recip engines, fuel cells, what-not, or just distributed generation, even for consumers with the solar+battery combo, then that means that you also have some sort of evolution — I won't say revolution, but evolution — within the power grid. Where I am actually moving back to a state where generation will happen with demand is to get around the grid issue because of the approval process, labor issue, and other myriad hurdles that are preventing supply of power meeting demand of power.

Rob Rowe (11:01)

Tony, on that, how are the regulators looking at independent companies creating their own generation vs. what's maybe on the power grid? Is there a demand that those generators be included in the overall power grid, or is it perfectly OK for a hyperscaler to create its own generation?

Tony Yuen (11:21)

This is a great question because it really depends on the different kind of jurisdictions or power markets, right? But also, if you're thinking about some of the underdeveloped side, as much as they want to be what we call "behind a meter," which is the generation will be behind your data center or what-not, basically also want to connect to the grid just in case they want electricity from the grid, then they can draw from the grid as well.

And then for the grid or the different power market themselves as well, because one will have to think about, If you introduce digital generation, how would that affect the community? And would that generation be taken away from power supply to other consumers? Or basically, you want that to be available for other consumers as well? So that's why there are different rules for different power markets.

And that's why, for example, in the U.S., PJM have to revise a lot of their rules as well. And MISO, which is Midwest Independent System Operator. BIRCOT, which is basically the independent system operator for much of Texas — the different rules. So that's why it also makes it complicated because of different regulators or self-regulating organizations, different rules for how they integrate these generations.

Rob Rowe (12:41)

And you mentioned natural-gas turbines and engines may be a top choice for BYOG. Could you talk about that a little more? Why are they so popular?

Tony Yuen (12:52)

Part of it is that the natural-gas turbines and engines are popular because they have strong reliability. Because as long as you have a natural-gas grid, you have the fuel source, and then you have the generation right there. These turbines or engines have been in existence for a long time. so you know that they can generate. They can also ramp up very quickly, typically not only in terms of providing general supply but also short-term boost in supply as well. Unlike, let's say, certainly building a coal plant will be difficult and of course nuclear — building actual nuclear power plants seems to take a long way, right? But then these engines or turbines can be small, can be modular, and you can combine them as well as you expand your data-center campus. So that means that you can scale, you can bring them on easier. But this advantage makes them highly popular, and so there's a lot of orders for these kind of generators and engines basically using natural gas.

So there's also a backlog of these turbines and engines, so much so that essentially the gas-turbine orders, for example, they typically average 42 gigawatts annually to roughly about 100 gigawatts in 2025 alone. So there's definitely big growth in that area.

Rob Rowe (14:21)

Do you anticipate, Tony, that the growth in AI will necessarily slow down as a result of this? Or do you think it's already happening?

Tony Yuen (14:28)

I think that the slowdown is actually potentially more short-term because you have seen that data centers either get pushed back, delayed, or canceled, right? But then these equipment, the power equipment, infrastructure equipment, as well as generation equipment, are based on orders, and a lot of them will start coming in basically by 2028, ‘29, 2030, right? So that means that you can see more of the expansion of these data centers as the equipment arrive, and therefore a data center, what we call the power shell, would be energized so they will have electricity to actually power these chips.

And then the other thing is how data centers themselves are using software techniques, right? Either pruning or become more efficient or basically some of the hyperscalers shift loads around, so they might be processing something in one data center, but maybe you need more power from other data centers that may be power shortage, then you shift the load calculation to other data centers, right? So definitely there are hardware solutions that are coming as well as software solutions.

Rob Rowe (15:37)

And looking at the overall global landscape, are all regions sharing a similar strategy on AI-driven power markets? And were there distinct approaches and challenges emerging worldwide? I'm thinking mostly about the U.S., Europe, and China.

Tony Yuen (15:53)

Yeah, absolutely. So the U.S. definitely is mostly driven power demand growth from data-center demand, right? And given that the U.S. has a big natural-gas pipeline grid, as well as abundant resources and low natural-gas prices, that's why if you look at Bring Your Own Generation, BYOG, it's really focused on natural gas.

But then in Europe they’re structurally somewhat distinct from the U.S. because there's a strong commitment to decarbonization, limited fossil fuels, and then a system that is more anchored around renewable generation. So what that means that they tend to generate higher electricity costs and also, on data-center development, they're still able to draw on their power grid but they develop more of the renewables side.

And then China is actually a quite interesting story. They have lots of resources, but they're also expanding. And so then that's why some of the experts on the tech side basically say that the U.S. is power-constrained but China's chip-constrained. But China definitely is building a lot of transmission lines. They're big in power-infrastructure equipment, the transformers, what-not. They're really expanding the grid. And that's why you can see that they have buildings, certainly data centers at different locations, facing less of a problem on the grid side and therefore less of a Bring Your Own Generation impact, but they are able to at least expand on the transmission as well as the distribution side of the power system.

Rob Rowe (17:31)

Excellent. Well, Tony, this is a fascinating topic. We could go on all day, but we'll be watching this closely. Thank you so much for your insights. And thanks to all of our listeners for attending our podcast.

This was recorded on June 18, 2026.

Disclaimer (17:50)