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CLAIR MOELLER INTERVIEW

Hi and welcome to GridTalk. Today we have with us, Clair Moeller who is Midcontinent Independent System Operator (MISO)President and Chief Operating Officer.

Q: Hi, Clair. How are you today?

A: Yeah, I'm doing well.

Q: Good. We're very pleased to have you with us today because there's a lot of meaty subjects that I want to dive into. You at MISO in the middle of the country at midcontinent are really at the heart of some major transformations that our energy grid is now undergoing. You just released a report that was updated in February called "The MISO Response to the Reliability Imperative." That's the platform I want to jump off with you.

A: Okay.

Q: It really captures a picture of an important grid serving 45 million Americans providing their wholesale

power system and reliability. What do you have to say on the topline conclusion of that report before we get into the nitty gritty?

A: I think the topline is, things are moving in an uncoordinated fashion where we're creating risk for the grid that we maybe didn't anticipate.

Q: Um hum.

A: Retirements are outpacing new installations of resources on the grid and that's a problem that we haven't had on the grid since its early formation period in the '30s.

Q: So, let's talk about that. The retirements have to do with your plans like other parts of the country to retire carbon-emitting resources. Talk a little bit about the carbon footprint of MISO and how you've been able to get it down and how you've achieved it.

A: Sure. Yeah, so in 2005 about 85% of our energy came from coal and last year, subject to check, it was more like 35%. That change has happened at a combination of the economics of the gas-fired generation are much improved over what they were in the beginning and also in excess of 10% of our energy currently comes from renewables.

Q: Didn't you get your carbon footprint down by over 30% since 2000 levels?

A: Yeah, that's about the number, yeah.

Q: And you have a gateway or a pathway to getting it down to 80%, right?

A: Yeah, so the plans that our member utilities present move our footprint down to about 85% reduction by 2040, 2045.

Q: And to understand the magnitude of that, you're in the Midwest, heavily reliant on coal historically coming out of Wyoming and the Southeast, is that correct?

A: Yeah, that's correct. We have coal facilities that burn both western coal and Illinois-basin coal.

Q: Um hum. So, your report goes into a number of problems that you're confronting and then I'd like to talk about that in a little detail and then we'll get into the solutions that you've been implementing.

A: Okay.

Q: Extreme weather. We think about what happened in Texas and its spillover effect a few years ago into the

Midwest. How extreme has the weather gotten and what are your forecasts and how are you ramping up to deal with it?

A: So, the actual magnitude of the event is about the same as it's always been but the frequency is increasing rather substantially. Climatologists' work indicate what used to be a hundred-year event is now like a ten-year event so we've had four serious winter events in 6 years and part of the reason they're serious is the changes in the generation fleet make it less reliable now than it was in prior years.

Q: What about summer and summer storms. Is the heat getting more hot and is that straining the system?

A: We haven't seen a significant difference in the summer. There has; there was one very energetic hurricane season that caused a lot of concern but hurricanes year-to-year are pretty unpredictable.

Q: What about the need or the transformation of your grid away from large baseload carbon-emitting resources to more resilient renewables. How's that create a need for long-functioning long-duration batteries, hydrogen, and possibly small modular nuclear reactors? And do you see

those coming on anytime soon; maybe you want to go one-by-one, tick them off?

A: Yeah, let's go one-by-one because you've got about two days' worth of questions there. The original model for the utilities, back to the beginning of utilities, was power plants around the city. SO the generation for the customers in the city was close and there were no reasons to tie cities together, not unlike like the interstate highway system, right. So the cities were taking care of themselves. In the middle '60's, they started to connect to each other for reliability reasons, emergency reasons. But they weren't meant to move a lot of energy from one place to another so that system was very well understood by the engineers. The traditional plants have some attributes that you take for granted that you have to engineer with the new fleet so your battery question is an example. Prior to 2005 almost all generation looked alike. You pushed a button, electricity came out. Storage was in fuel so you had a 30-day supply of coal out in the yard. So, we had energy storage but it looked like fuel storage. Since you move away from that traditional fuel is where you store your energy, things like batteries become

important because you still need that ability to fluctuate with conditions as conditions change.

Q: So, let's just focus on batteries for a second. You have folks out at MIT investigating new technologies. How does an organization like MISO monitor what's on the horizon and plan what you may be able to rely on and when it's going to be available?

A: Yeah, so we tend not to rely on things until they're commercially available. So today, the commercially-available battery technology is mostly lithium-ion. They're fairly short duration batteries, four to six hours. They do a wonderful job of helping you move; I call them a shape-shifter. They change the shape of the load inside a day; they're very effective at that. We see in California how they help with the ramping issues that they have as the sun goes down, the solar degrades but so far, that's the only commercially-applied battery we've seen is that fairly short duration.

Q: Let's talk about SMRs. Our last two podcasts in fact focused on what's going on up in Ontario which is not very far from you where they're bringing on SMR technology

within several years. Are you monitoring that and what role could SMRs play in MISO in terms of reliability?

A: So, the important thing of the small modular reactors is you have that long-duration energy capability. One of our bigger risks as we move to a high renewable future is typically there's a week in the wintertime when it's overcast and the wind isn't blowing. So I need a week's worth of energy at a time when renewables aren't producing and my batteries only have a days' worth of energy in them. So things like small modular rectors and hydrogen combustion are ways to fill that one-week long energy deficit and that will be very important to figure out how to do that on a cost-effective basis.

Q: Lastly, I brought up hydrogen systems. Do you see them ready for primetime anytime soon?

A: We haven't seen even demonstration projects yet. There's some in Europe but nothing here. There's a lot of research being done. There's coal-firing with natural gas seems to be viable in the short term but the technology to burn only hydrogen seems to be some years away yet.

Q: Those are the problems and the other ones listed in your report is supply chain and permitting issues. Why don't you tell us what do you mean by that?

A: Yeah, so we get a lot of critique about our generation interconnection queue being big slow and ugly but we've got over 50,000 megawatts of generation projects, mostly renewable, that had permission to connect to the grid but aren't being constructed. Over half of those 50,000 megawatts are more than 740 days late and when we ask why that is, the answers we get back is supply chain, dominantly labor as well as materials. Skilled labor is in short supply.

Q: Well, another podcast, in fact our most recent one is detailing how much money the federal government has been dedicated to just this, the grid through the Inflation Reduction Act and the Bipartisan Infrastructure Act, tens if not hundreds of billions of dollars. Do you see any of that coming into this critical juncture here of supply chain delays?

A: We haven't seen it work on the supply chain. We do have a Department of Energy grant to help fund some generation or connection investments but we don't see

investments in the supply chain happening very quickly. When DOE asks us what we think, we suggest they should focus on skilled labor training.

Q: Is that happening within MISO and are you playing a role in that?

A: Other than being the bully pulpit, we don't have much of a role there. We do have partnerships with various universities: Purdue, Iowa State; those sorts but the actual training of the skilled labor is outside of our purview.

Q: So, I mean just to put a point on it, why would a shortage of skilled labor result in over 700 days of delay in these projects that are ready to go?

A: Okay, just to be clear, it isn't just skilled labor but in the skilled labor market. So I've got two sons that are in the lithium-ion battery business and what they tell me is that the high-end technicians for inverters aren't there. So they need to wait for that labor before they can move to construction on their project. It's just a rare skill.

Q: So, back in July 2022, your board approved $10.3 billion dollars of projects; 18 projects to be specific,

which is the largest ever approved by a regional transmission organization and it's the first of four tranches that you plan to roll out. Tell me what is involved in that $10.3 billion and will it do you suspect, hit the wall of delays that we were just discussing a minute ago?

A: So, everything goes slower and costs more than you hoped when you approve it. Our first set of largescale transmission projects was actually in 2011 where we approved $6 billion dollars' worth of work. That was 17 projects, 16 of those are now in service and there's still one in litigation. So we expect that same kind of time signature on this first tranche of the long-range transmission plan. But that kind of matches the time sequence of everything else that's going on. So the plan we have to meet our members' needs for the decarbonization, the time signature … matches pretty much what their plans are because they have to get their generation house in order across that same time period.

Q: So, and to give people a sense of the large scale you're moving in, the scope of things you're contemplating here, that was $2.3 billion approved in July 2022. A

second set of portfolio projects is due to come out this year.

A: Um hum.

Q: Can you tell us the magnitude of that?

A: It will…

Q: And what will you layer on in addition to that $10.3 billion?

A: Yeah, our first estimates are $17 to $20 billion additional investments in transmission.

Q: So, and that's the second and there are two more coming after that?

A: Yeah, that's correct.

Q: The magnitude of those two, number three and number four?

A: I'm not even prepared to guess. By the time we're all in, it will be over a hundred billion dollars' worth of transmission investments.

Q: What would that buy in the Midwest? If you get it all on there with no delays, how would your organization look different?

A: Well, so its job is to enable $500 billion dollars' worth of new generation resources, right. So there wouldn't be any transmission were it not for the transition from fossil fuels to renewables. Transmission always follows the generation fleet. The renewable generation is widely distributed in terms of its siting, very different that the one-point source for a conventional power plant. So you have to build transmission in all of these places to pick up the resource and then transport it to the cities where the preponderance of load is. It's a very different system requirement than what the foundation of the utility infrastructure was.

Q: Paint a picture for us. I'm going to ask you to be a Monet, or a painter now. $500 billion dollars of transmission is coming to the heartland of America, is that correct?

A: Nope, nope. $500 billion dollars of new generation.

Q: I'm sorry; that's exactly right; $500 billion dollars. This area embraces Iowa and Kansas, two hotbeds of wind generation. Solar really has not taken off unless it has the southern footprint of this. What's the middle

of America going to be? What role do you see MISO playing with this $500 billion of generation? Will you be the muscle of America or is this being matched all around you as well?

A: Well, there will be some rationalization of what the resource looks like over time. Today, we actually have a surprising amount of solar seeking interconnect in places you maybe wouldn't expect it.

Q: For example?

A: Minnesota, Michigan, right; the latitudes are such that in wintertime those resources don't produce a lot of energy but the investment tax credits make economic sense to put them in the sub-optimum places anyway. So those kinds of things over time people will figure out that the production tax credit, the wind, keeps those located in the high-wind production places.

Q: This region and maybe you could describe it, goes all the way to Minnesota down to Texas, right?

A: Yes.

Q: And it touches part of Canada and Mexico as well?

A: Manitoba. I tell people we're the coast-to-coast RTO. We go from the Hudson Bay to the Gulf of Mexico.

Q: And 45 million wholesale end user customers is that correct, approximately?

A: Retail, yeah.

Q: And do you see this area…I mean, you talked a minute ago about the evolution of the grid; cities were serving cities and now it's becoming more regional. Do you see this region that you serve, exporting, being an exporter of energy to more distant parts of the country or is it all going to be an island unto itself?

A: I think that over time, this region will become an exporter because the land-use issues and the quality of resource diminishes as you go east; there's less wind , there's more clouds and there's more people. So just physically siting the resources is more difficult in those urban places and the physical size of these things is non-trivial. It takes about five acres of land for a one-megawatt solar farm. If you think about the population densities in the East taking hundreds of acres of solar collectors, in addition to where we can get on the top of a building, it's just the land usages will be non-trivial.

So siting the renewables where there's less population and density is where long-term this is going.

Q: Go down an economics path with me for a second; $500 billion dollars of generation, add-on transmission to connect it all. What's the impact going to be on electricity prices in your footprint?

A: So, it's kind of hard to calculate, right? It's also true that the energy that's produced is essentially zero cost. So we're trading marginal cost energy for fixed cost investment, but energy costs at the consumer level are going to go up substantially. It's not a cheap thing to deliver free energy.

Q: So, do you think the cost of energy in this region which is below the coasts might be closer to what it is on the coasts?

A: Oh yeah.

Q: A decade or two out?

A: I think that's true. And it will be higher than that on the coast, right, so the inflation will move; everything will have to move up in order to sustain that low carbon footprint.

Q: We've been reading a lot about the problem of single-site load additions associated with server farms and bitcoins. Is that causing wrinkles in MISO's territory?

A: Yeah, in addition to server farms and bitcoins, it's battery factories, it's the chip foundries. These industrial loads are in excess of 1,000 megawatts . So the infrastructure to serve them obviously isn't there yet. Part of this same planning problem is to make sure you can accommodate those. The difficulty is the commercial secrecy around them. You don't know about them until somebody's inked a deal and everybody's in a big hurry to get connected. It's hard to plan for those point loads. We've also seen some petrochemical large additions as well.

Q: So, some of the solutions that you've identified is refining generation resource planning. How's that working and how closely do you work with utilities and generators to make sure those plans are up to snuff?

A: In our part of the country the people who are responsible to make sure those plans are in place are actually the state regulators. State regulators and the utilities are on the hook for those plans and our job is

to help them see what the neighborhood is doing so that their plans are well-informed by the trends across the footprint. Let me give you an example of that. A solar farm, if you only have one solar farm, does a very good job of helping you defray the risk of a summer peak day. But if you have 10,000 solar farms, what you've done is change when the problem is to when the sun goes down. Well, you need to know that if you're a power supply planner that the neighbors are putting in a bunch of solar farms, too, so you know you can't risk removing the risk and you can't rely on just your summer peak load addition. Soit's become much more complicated for the utilities to understand and explore that. Our main job is to help them understand how that all works together.

Q: So, there's a questions of utility intelligence but what about MISO-level intelligence as the complexity multiplies below you, how do you solve it at your level?

A: We wrote the Reliability Imperative in part because we see gaps in what's happening and we need to proceed to close those gaps. An easy example is in our system operations function. In 2005 it was pretty easy. You predicted load, you turned on generation and if something broke, you turned on another generator. We're at the point

now where we have multiple meteorologists on staff because we have to predict wind speeds; timing of wind speeds; load; cloud cover, both how it affects load and how it affects solar output. One year we discovered we needed to account for smoke from Canadian wildfires because it had an impact on the solar output. So the complexity of making sure it all fits in any given day has moved from deterministic to probabilistic. We're spending a bunch of time and skill-building inside our system operations so that we can see more clearly what tomorrow looks like so we can the system to meet those demands.

Q: So, let me ask you a philosophical question. MISO is one of the first ISOs, is that correct in the 1980s?

A: No, actually we were 1998 we were formed. There were power pools before that that tried to function as an RTO but they were incomplete.

Q: Okay.

A: We were the first one that was approved.

Q: So, they were created at a different reality?

A: Yes.

Q: To serve a different reality. You're describing a much more complicated distributed model. Does the old system still make sense or what you're doing, what PJM is doing, what CAISO is doing; does it still make sense to do it regionally or should we have a super ISO embracing the whole country?

A: So, how big is too big to question there? As technology improves you can do better but I think the layered approach to operations, not unlike air traffic control, is how you'll see it all evolving.

Q: Um hum.

A: Right.

Q: Let's get into one question that's kind of suggested by what we're talking about, the need to maintain transition resources as we go to a less-carbon intensive system. How do you do the ballet dance of knowing how soon to retire something versus how long you need to keep it available until the new modular reactors and long-term battery storage become more ubiquitous?

A: Yes, so it's essentially an insurance pool. The the risk calculation of how many things are going to break, and do you have enough things to fill in the gap, is

literally an insurance calculation . We continue to do that insurance calculation. Challenges include, we're not quite sure what the statistics look like on the newer resources. But you have a good idea of what they are on the old resources. So, we used to have a whole bunch of simplifying assumptions that we could get away with because every generator kind of looked alike. We're having to revisit all of the math around how you calculate that risk and that's what we're working very hard at. You'll see regulatory filings at [FERC] where we're changing how we count, whether or not we can count on this kind of generation or that kind of generation. What we're doing is we're refining that risk calculation so we can tell people how much they need to keep of what kind of resource so that we can keep it reliable.

Q: Clair, the last question I want to ask you is since you've been at MISO virtually since its entire existence; you've been there two decades. Plaster on this report that came out in February is a big, black bold statement, "We must work together and move faster." You've been there 20 years. Describe this moment now how anxiety-creating it is? How exciting it is for you to be tasked with these challenges? How significant the transformations underway

will be, and how costly as you indicated, the price tag will be? How do you see your job and what's the most exciting about it? What's most terrifying about it?

A: The most exciting and the most terrifying are the same thing. The gap between retirements and the technology to replace those retirements I think is the biggest risk we face. So how to hang onto a safe transition is really important and there's a whole bunch of nuances in that. It's hard to explain to people but it's true that we can reduce our carbon footprint faster if we build more gas-fired generation so that we can turn off coal plants. You'll have to let them run and we only turn the gas plants on when we need them. But that just doesn't make sense to people that think we should turn off combustion because that's how you reduce the carbon footprint. So those kinds of educational exchanges are I think what is the most important part of what MISO is about right now. To help people see what their goals are and see what's the easiest and best, least expensive way to achieve those goals are. When we talk about that we call it least cost to achieve the decarbonization goals. And that's really important for everybody. Doing this wrong and creating reliability events will get us a backlash that would be

hard to sustain. So keeping it safe. People bet their lives and their livelihoods on us doing this right, so we've got to do it right.

Q: Thank you, Clair.

A: Thank you.

We've been talking with Clair Moeller, who's the President and Chief Operating officer of MISO, the Midcontinent Independent System Operator.

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END OF TAPE