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Transcript of **Technical Conference Day 1**

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Conference for North American Electric Reliability Corporation

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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION
(NERC)

Standards Committee and NERC Ride-through
Technical Conference

Wednesday, September 4, 2024
9:06 a.m.

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AGENDA

AGENDA (continued)

AGENDA (continued)

P R O C E E D I N G S

MS. WASHINGTON: All right. Good morning. Thank you for attending the NERC Ride-through Technical Conference. As a reminder to all participants, this webinar is public and is being recorded. The registration information was posted on the NERC website and widely distributed. Speakers in the room should keep in mind that the listening audience may include members of the press and representatives of various governmental authorities, in addition to the expected participation by industry stakeholders. Should you wish to ask a question during today's webinar, please use the Q&A feature in the bottom right corner of your screen.

Please note that there will also be a Slido during today's conference. It's NERC's policy and practice to obey the antitrust laws and to avoid all conduct that unreasonably restrains competition. This policy requires the avoidance of any conduct that violates or that might appear to violate the antitrust laws. Any NERC participant that is uncertain about the legal ramification of a particular course of conduct, or who has doubts or concerns about whether or not the NERC's antitrust compliance policy is implicated in any situation should consult NERC's general counsel, Sonya Rocha.

At this time, I will turn the webinar over to NERC Board of Trustee, Mr. Rod Manning.

MR. MANNING: That's working. Good morning.

PARTICIPANTS: Good morning.

MR. MANNING: Welcome, and thank you for being here. Many are here in the room. Many more, I think, are here on the call. I struggle this morning to describe this meeting. I was having a conversation with someone and I would say, it's going to be fun, and then I'd stop and say, well, perhaps it's not going to be fun. It's going to be exciting. Well, perhaps it's not going to be exciting. I think where I ended up with, it's going to be hard. I think that's fair. What we're doing is going to be hard. Perhaps it's evolutionary, I think, certainly evolutionary what we're doing today and tomorrow. Revolutionary? Maybe. Could be revolutionary.

We see the transformation of the grid -- we all see the transformation of the grid. It's happening all around us, whether we choose to technically shape the outcome or not. Sometimes I think if we choose to not take any action, the grid will transform itself anyway, but we all know that condition causes the latter to be less than the former, and I don't think any of us agree that that's acceptable, at least from a reliability perspective. None of us find this workable solution, I think going forward, and all of us agree that we need to act with contemplative intention or you wouldn't be here today. We need to think about where we're going with this.

I feel like today we meet head on one of our very first transformative decisions. I recently read the book, "The Last Days of Night," written by Graham Moore, and it's a story of Westinghouse versus Edison, a story of invention versus industrialization perhaps. It's a story of AC versus D.C. It's a great read. I highly recommend it if you're part of our industry. It's fascinating. Not everyone would find it fun or exciting. Some might find it hard, but I think if you've got any history in our business, you would really enjoy reading about the early days of the AC versus DC.

And as I was thinking about what to talk about this morning, I really thought about, you know, what we are considering over the next couple of days is a giant step towards rendering those prior AC/DC arguments, perhaps not irrelevant, but maybe extraneous. We're taking a big step forward, and it hasn't been easy to get to this point, and it won't be easy to find a pathway forward today and tomorrow. What we are going to do is going to be difficult. It's going to be hard. The good news is we do hard. We have a track record of embracing hard things and wrestling them to the ground.

So as we are about to tackle this hard task, it seems to me that there are three things that frame our pathway forward. First of all, the risk is sufficient.

The need for voltage and frequency Ride-through criteria has been demonstrated over and again. The incidents are becoming ever more complex. The potential impacts are becoming ever more predictable. To continue without addressing this issue really causes us to fail to address and remediate the appropriate risk. The risk is sufficient to take action. Second, the technology is sufficient. Now, we will hear more about that today and perhaps tomorrow, but it seems clear that what we want to do can be done with technology that is available. Finally, the time that we have taken so far is sufficient. We have moved through the full measure of process and engagement. We have heard from all front, we have taken information from all comers, and now the time has come for us to stop arguing and do something. We began studying this issue, believe it or not, in 2016, eight years ago. The time has come.

So there you have it. The risk is sufficient. The technology is sufficient. The time is sufficient. What remains is to just get it done. Hard or easy becomes irrelevant. All that remains relevant really is to chart a pathway forward, the pathway that sees us confidently step into the future of reliability. So that's why I'm here today. I suspect that's why most of you are here today, and I thank you for being here. I thank you for the skills that you bring to the table. I thank you for your engagement, for your knowledge. I thank you for your presence here in the room or on the phone. I thank you for your willingness to seek a solution where those who've gone before us have failed to find a solution. We're going to need all of your skills in the next 30 hours or so. Certainly what we're doing is evolutionary, revolutionary perhaps. The next few hours will write this story for us, so I thank you for being here, I thank you for your time, and I thank you for getting it done. Mark.

MR. LAUBY: Ditto. David?

(Laughter.)

MR. LAUBY: So anyway, good morning, everybody, and that's a wonderful setup for the -- today's meeting. I did want to kind of think about how we got here. And so I talked to my old friend, Faraday, who, in 1980 -- in 1830s, excuse me -- came up with kind of the first machine with a -- with a magnet and a spinning disc, and, you know, we've been making improvements to that from the beginning, DC machines, AC machines. I always want to start thinking about that group, AC/DC, but let's not go there, and the whole system, of course, being synchronized was a big, big chore. And we -- it was really all about managing mechanical energy, you know, taking mechanical energy and moving it, transporting it to where we need to use it, of course, then transforming that to actual work.

And when we think about NERC and all the activities that we all work on, it's all about avoiding what we call the evil three, which is the instability, islanding, and controlled -- uncontrolled cascading. In fact, Steinmetz has been quoted saying that we created the largest machine that people have ever built in the -- in the world with the interconnected systems. But, you know, it's kind of like when I'm listening to my 1970s and 1980s tunes on the radio and my daughters say, that's before the turn of the century, dad, because that's not where we are today.

You know, we have a significantly new way of generating electrons or exciting electrons, let's put it that way, because they don't really flow. They kind of get excited and bounce off each other. And not all of the transformation here is between mechanical energy to electrical energy, but rather, we're really managing the kind of the characteristics of a new type of resource in this case, solar panels, but even wind, though, at least wind has some mechanical energy. So there's no surprise that, you know, we have some kind of disagreements on the way forward here. It's a place that we haven't been before, and nd it disrupts a lot of the technology. It disrupts a lot of the -- kind of the rules of thumb that we're used to using and really kind of calls into question some of our fundamental assumptions, so, you know, Ride-through, of course, is just an important part of being able to go through the system events and avoid the evil three, right? And so it's certainly an important characteristic that the system should have to maintain the reliable operation of the system.

And we now have high-speed inverters that can really do whatever we want them to do, and we're trying to some -- in some cases try to at least mimic the characteristics that we need. But they have other characteristics, too, that we can take advantage of, and, in fact, they're critically important to the green transformation of the system, and we see inverters everywhere. Heck, my refrigerator's been out for like four months because I can't get inverters to fix it because they're putting them in cars and they're putting them in solar panels, and I don't have refrigeration. Well, anyway, that's another story. We should buy a new refrigerator, I guess. But this -- it's also a part of our -- now our inverter base loads. So how are we going to manage those? How are they going to sustain the reliable operation of the system? All this comes into question. So we are really here on a cutting edge, and, you know, there just -- there's a lot obviously that has to be done, and we really stand at the inflection point of this new system.

And I really -- to, you know, Rob's point here, thank you for all the work that you've done to date, how much work you're going to have to do to get us to that next step, an important, I think, inflection point in our industry. So as I mentioned before, Steinmetz was talking about the largest machine that was ever built. We're building the largest computer now, and it will be one that will be fast moving and can provide services that perhaps we never even dreamed of and be a more reliable, more resilient, more secure, and we need everybody's help to get there. So thank you. With that, next, I'll ask David to provide opening remarks.

DAVID ORTIZ: Thanks, Mark. Thanks, Rob. It's hard to hear yourself, right, stand right in front of the speaker. So maybe I'll start with a joke, I think. I had a teacher once that said that AC power was invented just so people would have to learn trigonometry.

(Laughter.)

DAVID ORTIZ: So my name is David Ortiz. I'm the director of the Office of Electric Reliability at FERC. I want to thank Rob for motivating the conference, Mark for his kind of technical insight. I'm here to provide just kind of a little bit of an overview on some of the process concerns and what our role is here, especially since a lot of what's happening is in response to a

FERC order. It's important to note, obviously, that I'm a FERC staff member, and these are my opinions and not those of the Commission or any individual commissioner.

As you know, Section 215 of the Federal Power Act describes the roles of FERC and NERC. And most specifically, the way it works is that those who run the system, those who build the system, those who plan the system, the ones with the expertise are the ones who develop the standards, you know, with NERC's assistance, and then those are submitted to the Commission for approval and/or directed modification, and that's an important role. And so really, the job is in your hands fundamentally, and that's the way it's been structured in the statute. NERC's rules permit extraordinary action in certain cases, especially with respect to a FERC directive, and that's the reason why we're here because of action that the NERC Board took a few weeks ago.

And then I want to note that, you know, I'm here and several other FERC staff members are here, and our role today is fundamentally as observers. We're going to have a really big bite at the apple in November after you complete your work here and NERC submits the standards to us. But the instigating action that kind of brought us here was Order Number 901, which the Commission issued in October 2023, and that directed NERC to develop reliability standards for inverter-based resources in four areas: IBR performance, data and information, model validation, and then planning and operational studies.

We gave NERC a really tight timeline for this, and, you know, we're not necessarily sorry about that, but it definitely is really pushing the limits of the processes that NERC has, and we appreciate NERC and all of you working toward those. You know, specifically, we ask that you -- that in NERC, finish the standards and submit those at the Commission for approval on a rolling time -- on a rolling basis in three years. And, you know, as you know, even a standard for which there is essentially no disagreement, just some details to work out, typically takes about a year to develop. And so to actually solve complex technical problems and submit to us a standard is a -- is a pretty high bar, and we understand that. And so, you know, to Rob's point, yes, this is a difficult task that we gave you, and to a certain extent, it's just beginning. You know, perhaps this will be a great conference and this will be a model for the next sets of standards, who knows, but, you know, there's still a lot of work to be done, and I want to thank Jamie for managing the whole endeavor. I'm surprised that she still has hair.

And I want to kind of address one thing with respect to Order Number 901. I know that within the discussions that you've been having specifically about this standard, but also about the standards which passed recently, there's been a lot of discussion about the order and language in the order. As a Commission staff member, and especially as an engineer and not as an attorney, I'm not in a position here to interpret the order, but one thing that I can say is that the way the Commission works is that it -- the Commission makes its decisions based upon a record. And that record that we -- that the Commission had in last October was what it -- is what it used in order to make the decisions in Order Number 901. If there is new information that's brought to bear that would cause the Commission to reconsider that, then that's something that the Commission has done in the past, and I presume it would be open to do -- to do in this case.

So for example, perhaps there's quantitative data about the capabilities of various inverter-based resources of various vintages, or perhaps there's some operations and planning studies that indicate that certain performance characteristics actually help to maintain reliability as opposed to others that have been proposed already. The more specific information that NERC -- that you provide and that you help NERC to submit in the record, the easier it will be for the Commission to make a decision regarding this standard and any standard, you know. This is just the way that the standards process works and the way that the Commission works.

The record, though, that we had indicates that this is something that needs to be done. As Rob said, this is something that NERC has been investigating since 2016 after the Blue Cut Fire disturbance and the -- and not only is this a -- an eight-year-old problem, at least, right? It's one that is -- there's a wave that's coming that's tremendously important for us to get a handle on. And that's the fact that, you know, EIA projects now, and it perhaps -- and this was last year -- perhaps it's changed already -- that fully half of U.S. electricity will be -- electricity will be produced by inverter-based resources by the end of the decade, right? So, you know, not only has it been a long time, but there isn't any time to waste.

So I appreciate everybody getting together, looking forward to just observing a productive conversation. Anybody wants to chat with me or staff, we're happy to have that conversation, but really, this is your time to do work, and we're just here to help. So thank you so much, and have a good day.

(Applause.)

MR. BENNETT: Okay. Good morning, everybody. Okay. So thank you for all the opening remarks from our -- from our three speakers that kind of help set the tone for the meeting today. So now my name's Todd Bennett. I'm chair of the NERC Standards Committee. I'm kind of here to walk through the objectives of the agenda, but, Mark, just so you know, it looks like we're going to do this through some high-voltage rock and roll today, so there's your AC/DC reference.

So first of all, thank you to everybody that has been involved in putting this together, so the panelists that volunteered, the NERC staff that helped coordinate a lot of the agenda, the meeting space, this location, all of that, as well as the Standards Committee members, so thank you to all the committee members. For those that may not know, that is a voluntary role, so this is in addition to their day job at their respective companies. So I want to say thank you to each one of those and what they've done to make this successful so far.

So let's kick this off, and, you know, our agenda, kind of just to review the agenda, I saw kind of three main objectives that came through the agenda upon my initial review. So the first one is very specifically on communication. So one of the objectives of this agenda was to communicate the technical issues and to level set on those throughout industry, OEMs and any of the other roles that we all play in industry. So we all come here, you know, and we're all going to learn something today probably just a little bit.

But then secondly, another objective is collaboration. And so some of the items that really spoke to collaboration on the agenda have to do with the panel discussions. So over the next couple days, there's several panel discussions on various technical issues with this project. In support of those panel discussions, I will say that Standards Committee and NERC did receive multiple sets of very, very technical comment and feedback. So first of all, we welcome that, that it was in great support of this Technical Conference. I do want to assure those that submitted those, that those have been reviewed by NERC Standards Committee, and the information contained therein has been used to formulate some questions for the panel sessions, so thank you for that. That really helps frame the -- frame the discussion.

So one thing you should be prepared for is there is a finite amount of time for each one of these panel discussions, so there's between 45 minutes or an hour or so. And there is a preset amount of questions, so there's about 10 minutes allotted for each question to make it through. Panelists may find that there's an opportunity to kind of build on some of the panelist responses before each subsequent panelist. That may be the case. If not, I don't want to, you know, frame your responses at all, but you may be able to make the most of our time and kind of build on some of the responses from before. So just be cognizant of there is kind of a time constraint on some of the panel discussions.

And then lastly, consensus. So maybe that's the main objective of this Technical Conference is industry consensus. How do we move forward? It's time to move forward. How do we take some steps forward? So we do have a tool that will help with that. I believe it was mentioned earlier, Slido. I've used it before. This is the app or the technology or the mechanism that will be implemented to issue some polling of the industry after some of the panel discussions. It's also a way to provide feedback during some of the panel discussions, so that is the chat mechanism for this conference. So you won't find that functionality in

Webex. It'll come through Slido. So there's more to come on that. There's more discussions -- or sorry -- more instructions on how to participate and the appropriate times to participate, so pay attention. More to come on that.

And with that, I don't think I have anything else to share. That's my agenda review. And I believe Jamie is ready to review the summary of the FERC Order 901 and Milestone 2, so we'll let her get set up here, and I believe she's going to go through a presentation with us.

MS. CALDERON: All right. Want to do a quick level set, so we're going to get really deep into the technical details during this conference which is good, it's why we're here, but we don't want to lose the forest from the trees type conversation, so let's take a step back. We're going to go all the way back in our time machine to October of 2023. David Ortiz opened it up for us, given us the -- kind of a little bit of the background on FERC Order 901 coming out.

So next slide, please.

Quick summary for everyone. The order came out in

October 2023. There are four milestones all the way through November of 2026, and they address a wide spectrum of IBR performance-related issues. Everyone here, I'm sure, is familiar with some of the performance issues that are in question. A lot of it has to do with making sure we have an accurate way that we represent them within models, that we're including them within studies appropriately, and that we're also just getting the data to begin with. So we want to be able to leverage the existing standards. It's not always a good idea to just come in and do a tear-down/rebuild when you don't have to, but we want to make sure that we're being able to implement meaningful changes within the standards. So if it requires a little bit of a step-back where a new standard, as we've seen with the IBR performance-related standards, that's one avenue to go to, and the team felt it was appropriate during this -- during these discussions this last year.

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So as indicated, there are really four main issues of this data sharing assuring that the data is available. We're talking about high-speed sequence event recorders, fault recorder data, stuff that has not been traditionally needed at conventional generation. So those needed to be installed, and we needed to ensure that the requirements were in place that required the sharing of that data to those who needed it, either for modeling or for doing those studies, or just for situational awareness, being able to monitor the onsite impacts and making sure that that was visible.

There's model validation, ensuring that not just once it gets thrown into the model, hasn't been validated. We're looking at also verifying during the interconnection process has the model accurately represented what was as built, if there was design changes that happened during the initial interconnection studies and we're moving into the post commercial operation, and it's not operating the way it was designed to as the way the model practices and simulation, then there's an issue there. So we want to make sure that we're building an effective model validation throughout, planning and operational studies that leverage that. And performance requirements were listed last, but, of course, we get to those first.

So next slide, please.

Another thing about Order 901 was that it references three different types of IBRs. So just to make sure that we're level setting on what those IBRs are, registered IBRs for the purposes of FERC Order 901, that is any IBR that is going to be registered as either, what we're referring to as Category 1 or Category 2. Now, the distinction between registered and unregistered IBR has to do with the earlier FERC Order 2022 that required the expansion of requiring new IBR generator owners to become registered and into the NERC regulatory environment. We're looking at aggregated IBR of 20 MVA and up connected at 60 kV. So this is an expansion of the IBR and generator owners. A lot more people coming on board.

In that original Order 2022, it was focused on registered and unregistered within that context. For FERC Order 901, "registered" encompasses both of those. So to be clear, that unregistered IBR is really focused on the not going to be registered, not part of the

Category 2 GO/GOPs that would be potentially interconnected at the transmission level. That would be looking at aggregated sets of IBR that will not have generator owners, but will be the responsibility of transmission owners to aggregate and incorporate into their models.

IBR/DR, similar conversation only at the DR level. So you're looking at the distribution level IBR, potentially rooftop, not to be confused with having individual model data for each of those, but the aggregated impacts to the distribution provider and ensuring that the distribution provider has at least some estimation for capturing those within their models and knowing the limits of their estimation. So if there's particular issues with acquiring the data, acquiring specific data, that that distribution-level data is at least estimated and being able to continue to be developed over time.

How we get that aggregation is going to be a continual conversation, but it's actually not part of the performance requirements in Milestone 2. The only ones that are identified within Milestone 2 are those registered IBRs that are going to be part of the Category 1/Category 2 generator owners. Those would be interconnected at 60 kV and up with the aggregation of 20 MVA and up.

Next slide, please.

Okay. So we are in the first stages of this. Again, it hasn't even been a year since the order came out. So putting this in context, you know, we had to go through some of the motions here. Rule 321 was something that we absolutely did not want to pursue if not needed, and it was determined to be needed in this case. We needed to make sure that we were having a really frank conversation on some of these issues and just an open technical conversation. But we don't want to lose sight of the fact that we have two additional milestones that will equally be exhaustive in terms of scope of work and the amount of time that it's going to be taking to get this together. We don't want to find ourselves in a similar position next year.

So this presentation and this whole conference, while we're looking at -- specifically at Ride-through and the very specific aspects, I know we want to get into exemptions and criteria discussions, but we don't want to lose sight of the fact that there's still a lot more that we need to be able to do and within the next two years. So the scope of work for November 4th, we look to be on track. We only have one standard that hasn't passed, and I think we'll be able to get to a solution at the end of this conference.

Next slide.

Okay. So just to break up the three standards. First Project 2021-04 at a new standard. Again, we decided to break out the IBR versus the conventional generation. So where we had PRC-02 that was focused on, you know, capturing this information, we've created a new standard. This Drafting Team decided to put forward PRC-028, looking at disturbance monitoring and reporting requirements for IBR. This is installing new sequence event recorders, fault-recorded data, and making sure all of that information is being provided through those requirements. So there might be a trigger, such as a request from a planner or operator, for that information. There's a small period of time that that data is just be -- required to be held on an ongoing basis, but we're talking about potentially terabytes of data after just a couple weeks. So there's not a large period of time that that data is required to be preserved unless a trigger is put forward by the planner and operator to initiate that.

So we want to get into how these things interrelate as part of this quick presentation, and I see this as part of like the three-legged stool that happens with real-time assessments. You've got data requirements, data-sharing requirements, and then the analysis requirements. The difference here is that we're initiating all three versions of this three-legged stool simultaneously. So this has been a lessons learned for how we do joint standard project development, three different projects working somewhat in tandem. Not everything was done completely. We got some lessons learned, I'll say, and some improvements that we'll make for the modeling aspects as well because there's three projects that will go through a similar type of need to coordinate and collaborate on a single solution.

So PRC-028 looks at making sure that the installation of the equipment is done. We'll get into the implementation questions and discussions tomorrow, so I won't go into the Phase 10 implementation through 2030, other than to say, for all of 901 -- that's Milestones 2, 3, and 4 -- all have to be fully implemented by 2030. It seems like a long time, but it's not. As we all know, just a standards development project is taking a year or two, acquiring vendors, getting through supply chain issues, making sure you've got contractors onsite for testing and validation. It's going to take a lot of work, and don't start two years from now or three years from now. It's really critical that we start soon and understand the issue soon so we make sure that things are in the works and scheduled and being able to be coordinated with reliability -- or with the regional entities as well.

Next slide.

For PRC-030 -- did we skip PRC -- did we skip a slide? Thank you. Yes.

So Project 2020-02, PRC-024, we're looking at frequency and voltage Ride-through requirements. It's why we're all here today. We're looking at establishing capability-based Ride-through criteria and performance-based Ride-through criteria. So the difference there being the design piece where you have -- whether or not you've communicated what the unit is capable of doing versus how it's actually performing in practice. During a voltage or frequency excursion, what is it actually doing? Does it match? And so we need both of those things in order to be able to align them and make sure that they're the same. There's going to be differences based off of things that are as-built versus as-designed, but we've got to be able to make sure that we're moving forward with comprehensive solutions. That means we need both of these, and that's what PRC-029 does for IBR.

PRC-024 was modified slightly. It takes Type 1/Type 2 wind. It takes synchronous condensers and synchronous generation. So we're retaining PRC-024 with those changes to ensure that those assets are covered. So PRC-029 really focuses on those asynchronous, you know, Type 3/Type 4 wind and PV where we're looking at IBR that need to be looked at a little bit differently.

Next slide, please.

PRC-030, similar conversation here where there was an IBR version of the standard created, looking at assuring that analysis is being performed. Who was the responsible entities, what were the trigger criteria, and how these things interrelate is that PRC-030 really triggers what is required to be evaluated. So within PRC-028, we talked about how there was disturbance monitoring data that had to be captured, that information needed to be triggered for. We're going to call -- we're going to investigate this particular instance. It's not going to be on the generator owner to know when a disturbance occurs. They're not looking at the wider area view. They may know because of their own operations that might trigger it, but it's going to be on planners and operators, primarily operators, to be able to determine whether or not excursions occurred that requires additional analysis to be able to identify if generators either failed to meet Ride-through or they were able to Ride-through with adequate bandwidth.

So PRC-030 is really what ties PRC-028 and 29 together. Again, that's that three-legged stool that are all really needed in order to be that single solution.

Next slide.

So finally, this is just a graphical representation of what I just went through. There's a voltage or frequency excursion that happens on the right and it -- for one, it's looking at the criteria individual generators will be able to tell if they rode through or not. And if that individual analysis doesn't occur because the generator owners didn't know that there was an excursion that occurred, then PRC-030 that's over there on the right-most block would be the one that triggers that additional analysis to ensure that it's performed.

The data-sharing aspect comes from PRC-028, so that left-most block. It's really going to be the thing that's going to be relied on to perform those analytics, but we got two other boxes down there that are critical, which is Milestone 3 and Milestone 4 are going to require this information. So having that data-sharing capability, the ability to trigger sharing that data is essential for validating models, making sure, again, as performance is being incorporated more into these standards, that we have performance evaluations during model validations and not maybe just five-year stage testing based off of what -- or the unit can do and based on the facts and circumstances at the time that unit is tested.

So model validation performance may happen on an ongoing basis, may be triggered on some other aspect of, you know, the operators or planners' criteria or working groups' processes. That's going to be developed within the modeling teams that are focused on Milestone 3, but we won't go into that today because that's obviously a whole other scope of work and we've got a whole year to do it, so we'll put that one to rest. Milestone 4 is taking everything that's captured in terms of the performance data and the models, and then conducting planning and operational studies after that.

So next slide.

At this point, we'll open it up for any questions. I don't know if there's going to be questions. If we can move to the Slido slide as well. Well, while that's getting ready just to go through how we're going to be doing the Q&A, within the room, we've got two microphones set up, which are between the two hallway the two columns here. If f folks have a question to ask in the room during any of the presentations or panels, please line up behind the microphones. We'll alternate between questions in the room and online. So the online Slido is going to be available during presentations. We're going to have the -- those questions locked so there won't be any questions that will be able to be asked at any other time. We're going to close that down and reopen it every time we have a -- the possibility to go to a Q&A.

We do have a code and instructions here coming up. There we go. Thank you.

So this is going to be the same information that will show multiple times throughout today and tomorrow. You're able to use the QR code if you want to scan on your phone. You are also able to just go to Slido.com. There will be a space to put in an event code. We're using "Ride-through" because why not? So capital

"R/hyphen/through." There's no password. You should just be able to get in. We will have moderated -- a moderator looking at the questions to make sure things are on topic, that it's appropriate to the panel that's being presented at that time. So this slide will be shown multiple times, so if you miss this information now, you want to grab a screenshot, please do, but that will be how we go through the Slido Q&A.

So if there's any questions online -- not sure if there's any questions online right now. Okay. Excellent. All right. I think we could probably go to the next presentation then, which will be a 15-minute break.

(Laughter.)

MS. CALDERON: Oh yes, yes. Question in the room?

MR. MAJUMDER: Thank you so much, everyone.

MS. CALDERON: Oh, just for anyone asking a question, could you please provide your name and who you're with, if you're in the room?

MR. MAJUMDER: Absolutely. My name is Rajat Majumder. I work for in Invenergy, which is a renewable energy developer here in the U.S., and I'm also on the Standard Drafting Team of PRC-029. So great presentation, good setup of the meeting.

I heard a statement from Rob that -- he made it very firmly that the risk is sufficient, technology is sufficient, so let's get it done, it's not a matter of easy and hard. Absolutely agree with that, but that risk sufficient part should be data driven. Yes, technology is sufficient. Of course there are -- there is gap between what technology can offer now, and that's why we are here today. Otherwise, we would already be having an approval on the standard. What is missing until -- is how the sufficiency of the risk is being established for what technology is shot. So that's what my humble request to the entire team, that as we go through next two days, let's keep that in mind, that whenever we are trying to establish a risk, let's find out what is needed for the reliability of our bulk electric system that we own. Thank you.

MS. CALDERON: Okay. Still no questions on online? All right. We'll go ahead and --

MS. CASUSCELLI: All right, Jamie. It looks like we do have a couple of questions online.

MS. CALDERON: Okay.

MS. CASUSCELLI: So first, "does the spoken word during this Technical Conference become part of the NERC/FERC record or only the comments provided in writing?

MS. CALDERON: Oh, yes. So we are recording this webinar or this conference. It will be posted. The transcript as we'll be able to have for our record of developments. Everything here for this conference is a little bit atypical because we're using it as part of the -- our response to invoking Rule 321, so this is going to be part of our full record of development. The questions that are online that are asked, we'll preserve those. We'll be able to add those to the archive of questions, questions in the room. We do have a court reporter in the room, and that's why -- one of the reasons we're asking folks to be able to provide your name and who you're with prior to asking questions so we'll be able to ensure that everything is -- everything's captured.

MS. CASUSCELLI: All right, a couple more. David McNeill from Certrec is wondering, "Does NERC anticipate the replacement of synchronous generation with IBR-based generation to lessen the severity of frequency events?" We'll probably get through that.

MS. CALDERON: Less than the?

MS. CASUSCELLI: Less than the severity of frequency events.

MS. CALDERON: Not sure I understand that question.

MS. CASUSCELLI: It says, "Does NERC anticipate the replacement of synchronous generation with IBR-based generation to lessen the severity of frequency events?"

MR. SHATTUCK: Yeah. I mean, I'd say probably not. I mean, the thing we can certainly say is that as we transition towards more IBR and higher penetration, things are going to change. If we do nothing, right, and it's all grid following inverters, and, you know, all the synchronous machines are gone, then things are going to happen that we don't expect. They will probably be worse than what we've seen. Now, if we do this in a thoughtful way and replace those synchronous machines with machines that are, you know, tuned right, with the right parameters or the right capabilities like we're going to talk about today, then we could be relatively certain, you know, if we go forward, that even if the events change their nature, that we're capturing that with our, you know, study work, right? If we do better studies and study what's actually going to happen and study what will come next, then whatever happens as far as the changes that happen, we'll be able to mitigate those as much as we can.

MS. CASUSCELLI: All right. Thanks, Alex. I have more. What is the code for Slido?

MS. CALDERON: There is -- so the event code is "Ride-through," capital R and then a hyphen. There's no password on top of that. So you're able to enter in additional information as optional, such as your name, so that we're able to respond to that question in chat, but the event code is "Ride-through."

MS. CASUSCELLI: And are the preconference comments going to be posted?

MS. CALDERON: Okay. The preconference comments that were provided as part of the larger set of comments that we requested from industry, we do not intend to publicly post those. We are collecting those as a matter of our, again, record of development. If we as part of our filing have additional follow-up questions, we might reach out to those individual comment submitters for additional information. If it's additional information that's requested by FERC during our filing, we're going to provide that as well, but we have no intention to post the full comments.

MS. CASUSCELLI: All right. Okay. There's more questions. We're getting more into, like, the technical stuff if you want to approach this now or --

MS. CALDERON: Yeah, if it's starts getting into the actual frequency or voltage criteria, we'll want to wait for that panel to go because we'll have an OEM panel today and another panel as well.

MS. CASUSCELLI: Okay.

MS. CALDERON: So as long as it's questions related to kind of the larger Milestone 2 work. Some of this, like, larger conference work stuff is fine as well since this is --

MS. CASUSCELLI: Okay. Okay. So we'll just hold a lot of these questions until the end, I think, or later.

MS. CALDERON: All right. Well, we'll put a pause now. We'll go ahead to a 15-minute break, and food, I think, is still probably down the way, coffee and water outside, and we'll see you in a bit.

(Break.)

MR. BENNETT: Okay. So it looks like we're getting started here. Again, I'd just like to say thank you for all the participants so far. Great technical presentation by Jamie to kind of set up this discussion. And then as far as right now, I believe that we have -- I believe that we are entering into our first presentation which is review --

(Technical difficulties.)

UNIDENTIFIED SPEAKER: Lithium batteries.

MR. BENNETT: Okay. This microphone works now. So we're going to enter into our presentation to review the voltage and frequency Ride-through criteria in the PRC-029 standard. So helping us with that are our speakers today, which are our Drafting Team members, but Husam Al-Hadidi and Shawn Wang. So I'll hand it over to you, and thank you for your presentation today.

MR. WANG: Thank you. Thank you, everyone. Good morning. My name is Shawn Wang from Enel. I'm the chair of the Standard Drafting Team. Yeah, I'm happy to present the -- some background of this standard development over the past, like, two years.

Yeah, maybe next slide, please.

Yeah. This slide shows the Drafting Team roster. I really appreciate all the membership, yeah, during the past two years. It's really hard work for the Drafting Team. Yeah, I think everyone actually here today just on behalf of us. Yeah. Actually, some of the membership, yeah, in this room -- in this room, yeah.

So yeah, with that, actually, next slide, please.

As Jamie, mentioned, the -- she just put the time machine back to 2023, but I will get back even further of this Drafting Team back to 2020 because the project named 2022 -- 2002. Back at that time, actually, there's a SAR from NERC to revise the standard -- existing standard PRC-024 to include the dynamic devices into PRC-02024. That project start from 2020. That's the reason why actually this project just grandfather that project to move forward to include -- associated with this standard.

Yeah. Next slide, please. Yeah.

Actually, in 2022, actually, NERC issued another SAR to revise the PRC-0-24-03, actually revise the generator Ride-through standard. The background for this SAR is like from the system events, right, several system events. Actually, after the analysis, actually, we -- the NERC team identified there some missed operations. Actually, the widespread generation loss actually reduced the output, right, from the IBRs from the wind, solar, or even the BES. Actually, the from -- the system event analysis identified there's some reliability risks, yeah, from those abnormal trippings from the IBR resources.

From the analysis, actually, the -- one of the issues is identified that the existing PRC-023 -- PRC-024-3, is just equipment protection setting standard. It's not sufficient to cover the IBR units. In that SAR, it's proposed to address those reliability risks to propose a more suitable performance-based reliability standard.

Next slide, please.

Yeah. The Standard Drafting Team start from actually combined those two SARs and start working on this standard -- the standard to work on this project. Actually, the project start from 2022, I think -- yeah, 2023. At that time, actually, after the extensive discussion, I think as mentioned by David and Rob, actually, the Standard Drafting Team realized that there's difference between the synchronous generator or the traditional generator and the IBR units. So approach-wise, actually the Standard Drafting Team decided to revise or modify the PRC-024-3 to retain the reliability standard as the protection-based standard, only applicable to the single generator and the synchronic condenser Type 1 and Type 1 wind turbines, and to create a new reliability-based standard, the PRC-024 -- PRC-029, address the inverter-based resources to Ride-through these system -- voltage and the frequency excursions.

Actually, at the time of the last year, actually, the FERC Order 901 came out. Actually, the Standard Drafting Team decided to coincide with the Ride-through standard proposed by the attribute standard -- no, sorry -- the need to understand and follow the FERC Order 901.

Yeah. Next slide. Previous one. Go back one slide. Yeah.

This slide shows the timeline, actually, for the Standard Drafting Team actually after the -- during the -- more than -- this year, right, after the 901 released. Actually, the Standard Drafting Team work very hard after that to meet the timeline, right? Actually, it's very time constrained. Actually, the first draft released in March of this year, and the first comment period run through March 27 to April 27. Actually, the first draft didn't pass the ballot, and they received almost 200 page comments from the stakeholders. The Draft Team were, again, working very hard, went through a series of meetings, including one in-person meeting in Cleveland in May, to address all the comments and release the second draft the -- of the standard.

So the second drafting -- the second comment period ran through June 18th to July 8th of this year.

Again, actually the -- it didn't pass the -- after received the comments, actually, the Drafting Team set up several meetings and address those comments, actually make revisions to the draft, actually, within very short time duration from July 22nd to August 12th. Then they create the -- make the third draft, but unfortunately, still didn't pass through the ballot. Then on August 15th, the NERC Board of Trustee invoke this Rule 321, so this technical meeting, yeah, yeah, came up. Yeah. So the -- just one thing I want to mention. The PRC-024, the revised PRC-024 passed the ballot, so we just focus on the PRC-029 now.

So next slide, please. Yeah.

So with that, actually, I will pass the microphone to Husam to describe the current or latest redline of the Draft 3.

MR. AL-HADIDI: Good morning. Husam Al-Hadidi from Manitoba Hydro. I'll just -- I'll go through the steps where we were as part of developing this standard with this Draft Number 3. Just I'll go in the progress how we came to this stage from standard from Draft Number 1 to Draft Number 3.

First of all, we were having challenging of the IBR definition, which was not there, and it gave us some way -- went through different phases of it, but until it was now approved by NERC, and it was passed the ballot. That's why it's now included in the -- in the standard itself. Also, there was some struggle with the transmission owner. Is it going to be part of applicability or not? And the reason for that is because we -- part of IBR, which is the offshore or any IBRs connected through the water source converter, which was sometime it could be owned by the transmission owner, but after a good discussion and looking at some example here in U.S., we found there is not a case exists, so -- and it was adding some confusion to the stakeholders. So we removed the transmission owner from the applicability part of it, and it's only now applicable for generator owner.

Next slide, please.

We started first with Draft Number 1, which was six requirement, but we ended up with four requirement in Standard Number 3, and I'll speak about why we have moved some of this requirement or remove it from Draft

Number 1. And the first requirement was about the voltage Ride-through, and in the first draft, we were having only -- it wasn't -- it was only event-based analysis. It was not a capability-based standard, but we understood that analysis part, it requires some measurement, and that measurement, it may not be available at the early stage of the implementation of the standard. And we thought it's the right way to go, is just to make sure that the capabilities already exist. And then event-based analysis will -- can confirm that if that's -- if it was how it was designed and it was -- performed as expected.

So we included the designing -- the design and operate, and it was -- that wasn't integrated in Draft Number 2, moved away from Draft Number 1, which was only about just operate the IBR, and R1, it just focus on the Ride-through the voltage. And we had two table for this Ride-through, and the two -- the table is one for the wind IBR and other -- and then -- and the second one for other IBR technology. And the reason for that, we want to have as wide as possible voltage Ride-through criteria with understanding that the system short-circuit level and they (inaudible) significantly change. And even the load itself -- IBR load will integrate it a lot on the system, and that the need of Ride-through -- of a larger voltage Ride-through, it'll be expected for ability to mitigate any future risk. For that reason, we were -- we went to the two tables and with understanding some limitation could still exist for the wind technology.

And here we have the -- we list some of the exemption from the voltage Ride-through where it could trip for a reason as listed in this fourth bullet. One of them is for (inaudible) protection, and second, we understood there's an exemption, and that exemption may give you a different criteria than what's there in the table. For example, like the 0.9 per voltage. It may -- you may not be able to go for three second. You may be able to go two second for legacy equipment only or legacy IBR. So that's the reason it's one of the exemption there.

And also Bullet Number 3, it used to be as a separate requirement in the standard in the first draft, which is the -- which is the positive sequence instantaneous voltage jump. But we said it was -- we thought it may -- it make it more fit to have it as an exemption because really only if unit trip, then if your voltage was -- if your base angle jump more than 25 degrees, then you could use it as exemption from the compliance part, and you don't have to worry about it as part of -- if you don't -- if you don't have a protection, if you don't have this trip there, so you don't have to be worried about the compliance and how to present it as a requirement.

And also, there was some question about the voltage per hertz, and we said maybe it's good to have some criteria to ensure just in the design because we added the capability and there was a compliance question how to prove that the design can work at the boundaries of the voltage and the frequency at the same time. That's why we included the voltage per hertz exemption criteria here.

Next slide, please.

This is the measurement. Actually, the measurement were changed somehow to reflect the -- some feedback we got from multiple stakeholder, and I believe to the stage where now it add more clarity. If you have any question, we can answer it at the end of the -- at the end of presentation. But for now, next slide, please.

For R2, I said R1 was still a voltage, but Ride-through R2, it went now to focus on the -- focus on the performance of the voltage. And here we split -- based on the table, there is three operating region, which is the continuous, mandatory, and permissive region. And for each region, we presented the performance criteria needed after a disturbance. However, we understood there is a weakness for every system, and you cannot come with some criteria which can fit all.

We try to come with as much as possible adding flexibility to the requirement, at the same time giving some guideline for a starting point whenever is needed. So we started with a lot of performance requirements as included and very specified, like it is going to be different how much your reactive power for every voltage there. What's the relationship between the power and reactive power?

However, but we understood that could be challenging for some region, and it will not fit -- we cannot come with answer fit all systems. For that reason, we remove some of this language from the standard, and we ended up with some language still there, which is meet the minimum requirement in our -- in the Standard Drafting Team opinion, but at the same time, having some added flexibility still there for the TB and for reliability coordinator and planning coordinator to come with their own criteria if it's -- if it's going to be different than this, to mitigate whatever reliability issue they have in their system.

Next slide, please.

For 2.2, this focus on mandatory operation region, where 2.1, it was the continuous within mandatory, and this one is merely saying that we understood there's a reactive -- there is real and reactive power. And we said that's always going to be the fault, is reactive power, it makes sense if you are having a voltage issue, you need to support the voltage system. However, we understood for system -- for other system, it could be real power priority is the need because they may have some frequency issue, and they need to mitigate it or deal with it.

So we come -- we wrote it in such a way where there is a flexibility there, but preference or the fault is already provided.

Next slide, please.

For 2.3, it is actually focused in the -- in the reaction of -- this one in permissive region where it's -- here, it's looking at part of the -- part of the FERC order was that you couldn't use voltage cessation or the blocking of the current. However, we understood that below 0.1, especially positive sequence voltage, if you have your three voltage phases already all below point-zero or close to zero, then it's very hard for the IBR to still continue to produce any power or try to contribute to the system.

So for that reason, we said, instead of allowing them to trip, we said, no, don't trip because really, it may, it may not able to provide any support after the fault recovery. So we say you could block if your booster sequence voltage below .1, but at the same time, if you booster sequence goes above .1 within five cycle, you have to reconnect to the system, and you have to start -- continue exchanging current, and you have to meet the requirement as stated in the 2.1 or 2.22.

For 2.4, it's focused on the -- on the response of the IBR after clearing the fault. It was a concern stated that sometime the -- based on the surface level or the -- or the gain, or the right -- or the recovery time, it may become a little bit -- or even the mode of operation is reactive power, how much reactive power was exchanged, it may cause a high-voltage response after clearing the fault, and that voltage may go outside of no trip zone, and that may cause itself to trip. So we see that it need to be designed or have the capability, and it has to be shown that it has -- it could be tuned to be able to maintain the response within no trip zone -- voltage no zone.

Next slide, please.

For the 2.5, this is for the recovery from the event itself. And for the recovery, as I said, the flexibility is added there. We said it needs to recover, and that was part of the FERC order, within one second. At the same time, it has to recover fully for the pre-disturbance megawatt, and -- but we understood that it may not be able to go to the full megawatt because of some water or some change in the -- in the -- in the -- in the capability of the IBR is not for tripping an individual IBR unit. It's only -- if it can -- even if we trip some IBR unit, but it can maintain its power after the disturbance, we say this should be a compliance. It shouldn't be -- have an issue with that, but we understand in some cases you may not able to cover for 100 percent, and we give them a flexibility, which is going to be provided by their associated transmission planner or operator or coordinator.

Next slide, please.

This is the fun part, which is R3, which is the frequency Ride-through. We had to struggle with this one, I must say. We understood the system is going to change in the -- right now, the system is going through significant change, and the IBR technology is going to be -- penetration will be increased significantly in the system. And people have not enough experience or exposed to the system to the high-frequency event or low-frequency event. So we try to write something which, in our mind, how it's going -- the system going to behave within the coming four, five, six, 10 years, and what's the availability needs for the system.

So FERC stated that you cannot have any exemption criteria. So we will -- we tried to write something which we try to have some frequency requirement there, performance requirement Ride-through, but at the same time with understanding some legacy equipment may not be able to meet some of these requirements. So we wrote it in such a way where we did not have any performance, only Ride-through, so we are not -- there is no primary frequency controller as part of this requirement. You need only Ride-through, and you need to keep connecting and exchanging current, but you don't need to respond to the frequency event as it is because there is no required frequency performance.

And the challenge was for the ROCOF, which is 5 hertz per second, but we understood it's -- this value cannot -- it's very difficult to calculate during the fault. So we make it very clear that this is not during the fault event. It should be after the fault and should be for really actual load and generation and balance event.

So and we come with -- we widened the table beyond even the IEEE 2008 and Ride-through, understanding that the nature of the system will reduce a lot, and we -- and the technology are much capable of Ride-through of frequency envelope. So and maybe today we'll hear from some -- OAM about their experience with that. But we widen this range of frequency larger than for the first -- six second larger than IEEE just to make sure that it's -- the future system will be able to have that advantage of maintaining the IBR for longer or larger exertion of frequency.

At the same time, also, the load will change significantly. IBR load will be there, and that will make rate of change, interruption of power will be significant, and the rate of change will be significantly, even most likely, more than 5 hertz per second.

Next slide, please.

The R4, it's -- is the exemption. In this one, we moved in different stages in our -- in our Drafting

Team to come to this language where it's in the -- in Draft Number 3. What we have here, we came -- we agreed that an exemption, this is like a temporary requirement because this one only valid for the first year of -- after the -- after the effective days of the standard. So after that, you have one year to apply for exemption for only voltage, which just mean that for R1 and R2. And for this, too, requirement, you could, if -- for legacy equipment, you could do exemption. We list some of the information need to be provided in your submission request for exemption. We understood there is a risk and some assessment need to be there, but -- that could not be explicitly provided in this requirement. But we said it's based on -- the exemption will be guaranteed not based on the risk. It just based on meeting this requirement itself.

Next slide, please.

Here, we also provided the mechanism and to whom this exemption needs to be submitted. At the same time, we said that how you need to deal with it in the future, if you are -- if your exemption has been -- you replace some of the equipment and if there is any request, additional information from transmission planner or transmission operators or RC for additional information. It could be modeling, it could be other information which may help them to assist the risk and to model or to try to include this as part of their study to understand their limitation within the equipment.

Next slide, please.

I think here, just the tables of the voltage and the frequency, so we have modified them, and there's not much here.

Next slide.

The same thing. This is the frequency, as I said. For the first six second, we have increase the level up to 64 hertz in the overfrequency part and to 60 56 hertz in the under frequency for six second. Beyond that, we try to match some of the existing IBR standards within the footprint of U.S.

Next slide. Thank you.

MR. WANG: Yeah. One more thing I want to mention is, like, for the -- at the first draft, right? We also include the transformer voltage, the requirement, along with the attribute and 800 standard. But during the Drafting Team, the development and also the participate of the attribute Standard Team, right? We realized that it's very complex issue at this point, and we just remove the -- remove that requirement and just put the one atom in the attachment of the Table 1, yeah, such that actually, we just try to avoid the instantaneous overvoltage tripping, yeah. That's not allowed, yeah. Just one point we just mention, yeah. Thank you.

MR. MAJUMDER: Thank you, Shawn and Husam. Rajat Majumder from Invenergy. I'll go straight to R3, of course. So two primary comments that I would like for the entire room to consider and provide some guidance. One is based on FERC Order 901. Is it true that the FERC Order 901 does not allow weaver to frequency, Ride-through, or 901 is silent on that. It does provide explicit weaver to voltage, right? So I understand that, but I just wanted to touch on that.

The second one, which going back to my comment earlier this morning, the sufficiency assessment of the risk should be data driven. And if we look at some of the earlier even that has happened, I fully agree that there has been, even on where large amount of IBR tripped off. Majority of them, if we review the NERC alert carefully were due to wrong settings. So if we try to solve a problem of some equipment settings being wrong with a very broad stroke of making the requirement much more stringent, I do not know if that's the right way of doing things.

If we look at, again, on the data that's available based on the Texas Uri event, the FERC report showed the frequency nadir was 59.4 hertz with 50-percent generation trip, then followed by 25-percent load setting. I was in Sigrid, Paris last week. There was a four-hours long session or large disturbance all over the world from both 60 hertz and 50 hertz, and many of them has significantly more IBR penetration in their system compared to here in the United States. I haven't seen any one of them, in 50 hertz, the frequency ever went down below 49.4.

So all I'm trying to say that asking for a frequency right requirement thinking it may happen in the future appear, to me, be pure speculation. So I would like the entire room to consider those fact and, again, humbly request to establish the risk sufficiency assessment based on data that's available to us. Thank you.

MS. CALDERON: All right. Jamie Calderon with NERC. Just in response to the question, the team was advised with Legal there was no exemptions that were allowed for frequency within FERC Order 901, so that was routinely provided to the Drafting Team through consult. FERC Order 901 doesn't even speak to any types of frequency exemptions. And we're going to get more into that conversation in this afternoon's panel and, of course, with the panel tomorrow morning. So we'll get into more details for that.

But also, just as a reminder, we do want to keep the Q&A to questions to either the presenters or the panelists. So please, please try to keep to that so we can ensure that we're allowing time for other people to ask questions.

MR. GOGGIN: Thanks. Michael Goggin with Grid Strategies. A question about the frequency Ride-through curves in PRC-029. Can you talk a little bit more about the source of those curves and the technical justification for the relatively wide frequency bands in there?

MR. AL-HADIDI: The idea behind that, we looked at -- I come from Manitoba Hydro. Our system, really, the inertia can go very low, and we have multiple event where we -- our frequency -- we have rate of change of almost 8 hertz per second based on our inertia when we -- when we, our tie line is broke from the system. So we understand the event can be very severely, and with low inertia, you need -- you need to Ride-through larger, wider range of band of frequency.

And we under -- also the base on this limitation we have right now in BRC 24, it was based on the actual physical limitation on thermal turbine, which is not the case in many cases for -- other than IBR, the Type 3, where it have some -- it's still in the integrated system. The other one is already buffered by the inverter itself. So we -- the thought was the opportunity is there. The need of the system will -- the inertia will go lower. Even the short sector will be going lower, and that's mean the rate itself can widely spread as a voltage dip where it can impact significant number of load and the load IBR base load. And this all can create a significant movement of the frequency.

In addition to that, also, we also understand that the IEEE say that 5 hertz per second. If you look about it, so it'll then take more than one second or less even to go beyond the 65 hertz or even to go 55 hertz if you are close to this 5-hertz-per-second rate of change. So it doesn't give a time -- enough time for the IBR to respond for a frequency event. So we said if the technology allowed that, why not to bring it, and the idea that it's not a protection base, it don't even -- in my opinion, the frequency or your protection setting should be based on actual capability and not based on the boundary itself as specified here.

So in many cases where we have our equipment, the Ride-through frequency in in many area, like Manitoba Hydro have, we have up to 82 hertz. It has to Ride-through. So this number, in my opinion, was insignificant based on the system need and the system need maybe there in the future. Thanks.

MR. PATEL: All right. All right. It's working. So you know, everyone is going to talk about frequency Ride-through and exemption for legacy. I'm not going to talk about it just now. But by the way, Manish Patel, EPRI. Whatever I say or ask are my own opinions and questions. Please don't sue me. I still have two young daughters to send to college.

(Laughter.)

MR. PATEL: So a couple of general comments. Look, I'm supportive of the standard, but the standard remains completely silent on when IBR is required to Ride-through, for what system conditions. The IBR may be designed today, installed today, commissioned today to Ride-through for a given system condition. Ten years go by, the transmission system has changed upside down. Is IBR still required to Ride-through? I think -- I think it's a -- it's a -- it's a gap that the standard completely remains silent and simply states Ride-through no matter what the transmission system condition is, what the neighbors are doing, and all that kind of stuff, right?

The second thing is the way the standard is written right now, if the differential protection on a generator step of transformer mis-operates, then the IBR is out of compliance because it tripped when it shouldn't have tripped. I do not recall exact details, but in 2022, there were 1,200 mis-operations on the bulk electric system, and it's just life happens, right? So there has to be some exemption for things that are beyond control, right, water dripping from the roof in a control house, mouse in a control house chewing up cables, things like that. We talk a lot about what IBR is expected to do in a continuous operation region of the voltage. I think that is probably unnecessary requirement because the whole purpose of the standard is Ride-through when the voltage and frequency are normal. Half of the page of the standard is actually asking for IBR performance when the voltage is almost normal, right, so things like that.

I had something else in my mind, but it's slipping. I have opportunity today and tomorrow then.

MR. AL-HADIDI: Thank you for the questions. Manish, we discussed some of this one before. So maybe in the first part, which is about the system strength, where it was -- where it was designed, the idea were -- the team were, the Drafting Team, that we did not touch the stability part of the IBR. So we said we are -- in the standard itself, we did not speak about the, what you call the rising time or starting time, or is going -- is it going to be stable or not stable. So we understood this can impact the stability, and there's the third phase, which is the Milestone Number 3, which is, you know, about the operation, and that need to be caught at that stage of the analysis, and I believe that will be -- could be advised to revise some of these parameters or re-look at it as part of that -- part of investigation.

But if it -- if that part provide now recommendation for change of that to maintain for whatever short-circuit level system become because you cannot say that I design today, system have changed, now for reliability, I don't have to do anything about a system change. System event happened, everyone cannot Ride-through, and the system can collapse or reliability issue. So I think that need to be addressed as part of the how the phase three or my phase three of the standard need to look at it, and in that case, we looked at it where it need to be looked at, the stability of the IBR.

For the second part, I believe your second question, if I remember was about --

MR. PATEL: Mis-operation of protection.

MR. AL-HADIDI: Mis-operation, yes.

MR. PATEL: Just real-life things.

MR. AL-HADIDI: Yes, I fully agree. Where the standard -- we work with the BRC/TRT. As Jamie stated, that these three standard really are -- they were integrated with each other to some level, what our -- the Standard Drafting Team at least thought. Maybe it wasn't clear. We'll see how the thing goes. We thought that the BRC 29 provide the criteria itself. However, the assessment itself is done by BRC/TRT because there's even the correction plan. Everything is coming -- going there.

In the PRC-030, it was very clear stated that if it was for mis-operation, you don't need to investigate it, and is no -- no corrective action is needed. So it was already exempt by the IBR tripping for -- mis-operation protection was already included, in our opinion, at least in the PRC-030, which maybe this a good point for discussion, if that was really the right way to do it or not, but that's where we are.

MR. PATEL: Yeah. So I understand that. The standard has to stand on its own, right?

MR. AL-HADIDI: Yeah.

MR. PATEL: PRC-030 only talks about the operation of BES under PRC-004. You can have a collector feeder breaker trip because of, you know, real-world issue, and that's not a BES element. If it's not, then it's not part of PRC-030, but PRC-030 criteria is met and PRC-029 criteria are met, right? So I think -- anyhow, there has to be some indication of things in the standard. Right now, the way it is written, voltage was in the mandatory operation region, frequency was in the, you know, mandatory operation region plan disappeared, and there that has -- it's out of compliance. Anyway, we, we can talk --

MR. AL-HADIDI: Yeah, yeah, that's a good point. That's a good point.

MR. PATEL: Yeah. The last point that I just recall is this whole concept of performance-based standard. I think when the whole idea of performance-based came along, it was not the fact that perform under 24/7, 365, next 25 years, in that manner. It was more about voltage and frequency trip setting. PRC-024 is not working. We need to go for performance-based. Performance-based was -- continue to work when the voltage and frequency are within given bends, right?

MR. AL-HADIDI: Yeah.

MR. PATEL: So this whole concept of performance-based is a little bit misaligned than the original thought five years ago when it came out of IRPTF at the time.

MR. AL-HADIDI: No, I agree. Thank you.

MR. MAJUMDER: Rajat Majumder. So Husam, when you responded to the other gentleman question, I have heard many will, and you referred to Manitoba system. Now, I'm sure that you might have seen an ROCOF of eight hertz per second. That's shocking, but we cannot take the requirement from a very specific region and generalize it, right? Again, referring back to my

SIGRA session, there was a gentleman from South Australia. He presented a lot of experience with a peak load of 3 gigawatt. Now, are we going to take a South Australian event with a peak load of 3 gigawatt and apply that to Eastern Interconnect with 950 gigawatt? So when we are creating a reliability standard, we need to be aware of the context of it. Cherry picking and then applying blindly is not the right way to do.

Second of all, you mentioned that, well if the design can do it, why not? It's not about just the IBR. We'll have transformer which are not under PRC-029, and I don't want to speak for them because we have enough expertise today within the room. I'm looking forward to the manufacturing panel this afternoon. We have representative from FOSDA, Siemen Gamesa, Hitachi Energy. They are the top at their field. Please hear from them. If you are going to have transformer operating in such a low frequency ban, there are going to be many other issues, unintended consequence. It's going to make the transformer for no apparent reason. That's not the right thing to do, but transformer is not covered within our PRC-029.

MR. AL-HADIDI: (Inaudible) versus (inaudible) hertz was addressed by R1, but as I said, let's maybe -- let us leave it -- this topic for further discussion within the industrial, what do you think about the frequency range and if the capability's there or not, and what's was really the concern. But we did not get too many comment from the stakeholder about the range of the frequency. Most of their concern was with the ROCOF and the legacy equipment where it may not able to ROCOF value.

MR. MAJUMDER: Yeah.

MR. PATTABIRAMAN: Hi. Dinish Pattabiraman from TMEIC, you know, equipment manufacturer. So I have a question broadly on the standard in terms of why the deviations in the standard compared to IEEE 2800 language, which has been widely accepted in the industry with the high balloting rate. And there's also about to be a test procedures, IEEE 2800.2 that's going to come for the standard. Why deviate from the language of IEEE 2800, which is widely accepted in PRC-029?

MR. AL-HADIDI: We did not -- our intent was not to diverge or to follow IEEE 2800. We started there, but there was a lot of requirement there, and some of it actually to be hard to write it, or maybe to moderate, or make it as part of the compliance itself. So based on that, we looked at the variety of the need for the system and from reliability perspective, that was the intent. And wherever we found the reason to divert from it, we did. And it was also, as you know, it was FERC order, was also constrained in the way we looked at some of the requirements.

MR. PATTABIRAMAN: So but in terms of compliance, you know, 2800.2 also offers a variety of test procedures. I'm not sure if there's going to be a test procedure that comes for PRC-029, but the strength of 2800 is that it offers these kind of test procedures which different people can study and comply -- and at least study compliance with, whereas deviating from 2800 language -- for example, there is a language for phase jump that says that, you know, 25 degrees but initiated by a non-fault, you know, that kind of language was not there in 2800. There are small changes like this throughout the standard, including the frequency Ride-through requirements. So I'm just curious on what the thoughts of the Standard Drafting Committee are on that.

MR. AL-HADIDI: As I stated that, yes, there is some slightly different, but I'm also part of the -- of IEEE standard, and it's not -- it's not the perfect standard. And all it mean that there is always need to change, and there was opportunity for us to look at from a bit perspective like the frequency, why it's there. And when we asked the question even why this value was selected was not enough, always a good answer from people who were involved in IEEE standard at that stage.

So it's based on the -- your experience, and this is the task of the dd task of the Drafting Team to come and consulted with the industrial and the feedback we got, and based on that, we moved in this direction. Thank you.

MR. PATTABIRAMAN: Thank you.

MR. WANG: Yeah. For this one, I think two parts I address. Yeah. For the 29th standard, right? I believe most of the -- especially for the voltage part, pretty much align with the IEEE 2800 standard, yeah. I think for frequency part, yes, actually there's some division, right? So for this issue, I think even for this -- even within the Standard Draft Team, that's the ideal -- the approach we adopt so far.

For this Technical Conference, one of the main purpose for that -- for this conference is, like, we discuss the frequency part, right? I think for that part, actually, we have that dedicated topic to discuss that one, yeah. If the OEM even for the for BES or even for wind manufacturer, right, if has any not issue or concerns with that -- with that standard or the requirement, yes, we -- the Standard Drafting Team really want to hear the voice, yeah. That's the one -- the main for this one.

For the second one, for the -- for the testing procedure, right? I know the IEEE standard, the 2800.2 is working on that testing procedure. I think it is still ongoing efforts, right? The Standard Drafting Team has very closely participate that -- the working groups. Actually, we just adopt that approach maybe in the future for the -- for NERC standard, right, for 29 or even the future, the revisions, yeah, for sure we can adopt that approach in the future. But at this point, I think even for the IEEE 2800.2 is still ongoing efforts, yeah. So that -- I think I just want to bring the attention to the team, yeah.

MS. CASUSCELLI: So we've got a number of questions online. I'm just going to interject here. Could you share the evidence or data that NERC has indicating that the bulk power system might experience frequencies up to plus or minus 4 hertz per six seconds?

MR. AL-HADIDI: Even we don't -- we cannot present information for even the current -- whatever their IEEE standard, which is the 57 hertz. So the evidence, you don't have an event because once event or under -- or once event is very rare event. When it -- when it happen, you need to have a system, really, which can be very robust and very reliable to deal with it because when it happen, there's a blackout. There is really a big system event to start with. So really, likely the -- where we are right now in the system, based on where we are and hopefully -- and that's where -- that's where our standard is moving, at least hopefully, to prevent us from being to that stage. So no event -- there is no event happen to support even any frequency, even 57 hertz, which is there in IEEE standard. It was -- we cannot -- we have no event to support that in overall system. Thank you.

MS. JONES: Hello. Rhonda Jones from Invenergy, and just building upon then some -- like, when you look at the 10 system disturbance events that were used in the analysis, it never came below 59. So just curious when the widened bands were established to also -- they considered current-day needs and a little bit of projection or forecasting for future needs. One of the things that I'm trying to work to reconcile is, currently, right now, the interconnection dynamics were considerations when you set -- when the bands were set in the past. And I'm curious how those unique dynamics were considered now just having one big band that covers everything versus consideration for tailoring the bands based on the interconnection dynamics.

MR. AL-HADIDI: Let me see if what -- if I understand your question about the reaction of the IBR or to -- how to recover from the frequency itself, and that's why the six second was giving the IBR time to respond to the frequency and try to -- because it has some time response. And in our standard, we did not come with a performance requirement, so it could be performed within four second, five second. It's much faster than synchronous machine to respond to the frequency event, so hopefully that in the future will be able to recover the frequency much faster. That's why we thought the six second itself is the time where it give enough time for the IBR technology to inject or remove power from the system to respond to the frequency event itself. I'm not sure if I got your question. Sorry if I did not get it.

MS. JONES: That was part of it, but I think the biggest thing I'm trying to understand is that the mix of generation in a specific interconnection does impact inertia and frequency performance.

MR. AL-HADIDI: Yeah.

MS. JONES: So I'm just wondering consideration for bands that are more accustomed to the dynamics of an interconnect versus just a broad, no matter where you are, this is what you need to do because there is some benefits to having it tailored in that way. You know, when you look at the events in the East versus the Western interconnect, the evidence is very distinct on where the concentration of some of those misses were, which are primarily contributed to settings, which is human error versus not being able to perform enough. Was just kind of curious about maybe tailoring the curves more to interconnection dynamics and generation mix as opposed to just a one-size-fits-all.

MR. AL-HADIDI: That could be an approach we could -- we could use. Actually, there's nothing wrong with that. It's the only thing which -- in my opinion, it's still -- there is a lot of unknown, and we know that systems going to change, and the way it change is going to be more and more sensitive to the frequency event. Load itself is significant. It's going to -- we have too much IBR load technology, which is going to come in, and some of these one actually the trip themself or remove themselves at certain voltage. If you start removing significant amount of load on and off, that will generate fundamentally very significant frequency change.

So really just to be careful where -- we thought we are -- a second part of discussion where the industrial is heading. Is it something which we -- if there is no actual limitation, what's the harm of getting there? There is -- if the cost is reasonable and it meets some reliability in the future and even some into the system, we thought there is maybe no harm. But if that's not case, we'll see how the thing goes with input from the OEM about if there's a concern or not. Thank you.

MS. CASUSCELLI: Thank you. One more question from online here. Can you discuss the data requirement in the measures?

MR. AL-HADIDI: Sorry. We didn't get the question.

MS. CASUSCELLI: Can you discuss the data requirement in the measures?

MR. AL-HADIDI: Data requirement is already established in the PRC-028, so PRC-028 established data requirement for the measurement

MR. VENKITANARAYANAN: Morning. My name is Nath Venkit, and I'm from GE Vernova, and my question is on the -- on the requirement that inverter-based-resources should not trip on instantaneous overvoltage, which I completely agree with. But the concern is that individual inverter-based resource units, based on the language in PRC-029 -- I believe, it's footnote -- or, you know, Note Number 10 in Attachment 1 -- should have a filtering for one cycle before they trip.

Now, I was part of the Drafting Team for IEEE 2800, and this was discussed pretty extensively, that standard. IBR-powered electronics do not have that kind of long duration overvoltage capability. So the compromise that was established in IEEE 2800 was that the one cycle filtering requirement was applied for any protection at the plant level that would -- that would disconnect the entire plant. For example, if you had an overvoltage relay, then you would need that kind of, you know, filtering.

However, for IBR units themselves, the standard did not just give them a blanket exemption. 2800 specified sub-cycle overvoltage Ride-through requirements that individual IBR units had to withstand, right? So it wasn't a requirement to wait one cycle before you trip for any overvoltage, but a more rational requirement for sub-cycle overvoltages. For example, the IBR unit would need to Ride-through and overvoltage of 1.8 per unit for one millisecond. So that's one of the requirements in IEEE 2800.

So the way PRC-029 is written, I think we really have only two choices, right? If you have a very large overvoltage that is imposed on power electronics, then you can let the inverter trip, protect itself hopefully, and come back online within a few seconds or a few minutes, or if you don't allow it to trip, then the choice is the inverter gets damaged, then trips and will take several months or years before it can come back online. So I would -- my question is, why is the requirement not more specifically calling out sub-cycle overvoltages for individual units to withstand?

MR. AL-HADIDI: We were there first. We have -- it used to be in this Draft Number 1. I believe it was R4, we're dealing with the transient overvoltage. However, we were -- basically even -- whatever we see right now in IEEE standard, they are having very difficulties would -- come with some mechanism how even to do the measurement and calculation for this transient overvoltage, and we felt that the industrial is not in the stage where it could have that -- the work based the PRC-028 and how the mechanism, how to calculate it. And it's -- we thought it could be very difficult to come with way to try to be measuring the compliance of that event.

The question will come, why the system -- why the IBR is going to see 1.8-per-unit voltage? Is it because of the switching within the IBR itself with some things a design issue, or is it from the system event? If it's from the system event, I don't believe there's any system event. The voltage can go transiently to 1.8 without impacting -- overall, you'd be -- you'd be with the filtering time of even one second one cycle, most likely that will lead to your voltage to be fundamentally above 1.2, and we could trip for the overvoltage.

We had a struggle on the technology itself, how to do the measurement, and that's why we feel there is the best way, try to move away from this requirement, become very specific, become challenging to meet the compliance part of it. And that's why we moved away and to remove it. And we compensated with a filtering to ensure that if it's a protection -- transient overprotection, then you have to protect it in this way. But if it was internal issue, you have the arrestors. You have different mechanism to deal with it, able to deal with the overvoltage during -- as a result of a switching within the IBR facility itself, so, and that's part of your design. As a design, that's part of it, but we were mainly concerned about the system event, and we did not see a way where we can capture system event for that reason.

MR. WANG: Yeah. I just want to add some background on the -- on that requirement, yeah. So in the IEEE 2800, right, that's the -- that transit overvoltage specify at unit level. That's the -- that's the -- I think that's the requirement.

MR. VENKITANARAYANAN: It is at the --

MR. WANG: Yes. For PRC-029, we didn't talk about the unit level. We just look at the POI, right, or POI in -- along with the IEEE 2800. Another issue, we -- the Standard Drafting Team deal with this. For the -- actually even the IEEE 2800.2, Subgroup 2 and 3, we had very, very lengthy discussions, yeah. If we supply that at POI, right? So let's do POI, the high set of transformer. Even the -- even the high set of transformer endurance, the experience of that high voltage, right, transient overvoltage, based upon the BOP of the plant, it's very complex. The issue actually to reflect back to the terminal, yeah, right?

That's the reason why we -- the Standard Drafting Team facing in the -- for the challenges, right? Even if we apply the highest -- high set of transformers that, say, like 1.8 per unit high voltage, it's very hard to identify what high voltage experience in a terminal. That's one -- another reason we remove that requirement to the Note 10 now, just based upon the previous event analysis, right? We just avoid, say, like, the -- just like (inaudible) suggest one, two points, yeah, just trip off the units. That's the -- that's the base -- the rationale at this point, yeah.

MR. VENKITANARAYANAN: Right. I understand, but I hope you understand there are only two choices. One is the IBR trips to protect itself and comes back online within a few minutes or seconds, or it gets damaged and still trips and is not able to come back online for several months or years. So with that, I'll end my question. Thank you.

MR. AL-HADIDI: The standard didn't go that far, and as I said, we don't have any measurement on the unit itself. Our requirement from PRC-028 is only at the high side of the transformer, so there is no mechanism to come with any compliance requirements for it. That's the reason we're -- where we are right now.

MS. CASUSCELLI: All right. So I need to issue a two-minute warning here, so I apologize to those in the room who can't ask their questions. So I'm going to ask one from online here. What measures did the Drafting Team take to ensure that IBR owners do not bear a disproportionate responsibility for system frequency response?

MR. AL-HADIDI: You have to Ride-through it. I'm going to say they have to Ride-through it. They need to Ride-through it. So it always need responses, same event, and their equipment needs to stay online, and the standard is not requiring them, as written right now at least, to provide a frequency support or any performance. So no performance compliance is just to maintain -- connect to the system and Ride-through the event itself.

MR. HAKE: Hi. Sam Hake with a AES Clean Energy. We're a renewable energy developer, and I'll try and keep this quicker. It's a little bit less of a technical question. So I wanted to focus on the language in R4 that talks about hardware-based limitations. We have some concerns that we have legacy sites that may have -- we may need exceptions based more on modeling information, either availability or quality of the models, in order to demonstrate and determine if sites can be compliant. So the question is, why is there that focus on hardware-based limitations in R4 that seems to exclude some, what we believe, valid software limitations?

MR. AL-HADIDI: It's for modeling or for the voltage, Ride-through, you mean to say, because this standard, it doesn't deal with modeling. Maybe I

misunderstood your question or maybe I --
MR. HAKE: So the language in R4 talks about exceptions for voltage Ride-through --
MR. AL-HADIDI: Yes.
MR. HAKE: -- based on hardware --
MR. AL-HADIDI: Hardware limitation. Yes, you're right.
MR. HAKE: Yeah. So my question is why hardware limitations only?
MR. AL-HADIDI: Okay. That also came from the FERC order. FERC order stated very clearly that any voltage exemption need to be based on the hardware equipment, not the software. So we tried to -- when we are constrained with some language, so we -- and we understood some -- and you're right. Some software could be very challenging to deal with, but we understood by "software," if something could be dealt with, if it's not really something which you couldn't update different or upgrade your software, it become really hardware limitation at that case.
So we left it open, what do you -- what you guys can come with the hardware limitation. In my opinion,

if you cannot do anything about your software because it's become hardware limitation where the version of it or the -- is not enough or it's not in capability to upgrade, it could become a hardware limitation, but this is my interpretation. It's not NERC or FERC. That's my opinion. Thank you.

MR. HAKE: Right. I appreciate that, and I think that's exactly the concern, right, is that it's open to interpretation.

MR. AL-HADIDI: Yes, you're absolutely right.

MR. HAKE: Thank you.

MR. BENNETT: All right. Thank you, everybody, for the wonderful questions, both in the room and online, but I think it's time -- we need to transition to our next presentation here, but before we do, let's -- our two friends here in the hot seat from the -- from the Drafting Team, why don't we just give them a round of applause real quick? They've done a great job.

(Applause.)

MR. BENNETT: So as they exit the stage, let me just tee this up for Alex. Our next presentation is a very similar subject, another review of voltage and frequency Ride-through criteria. So to walk us through this, this is Alex Shattuck from NERC, and yes, I did pronounce his last name correctly. So, Alex, please help us out with this. Do you need a microphone?

(Brief pause.)

MR. SHATTUCK: Thank you very much. My plan today was to present a bunch of objective facts. It seems like a bunch of y'all did your homework, and a lot of what I'm presenting, we've talked about through the questions and that kind of thing. So the goal here is to just present some information and some data and some observations without giving any opinions. If I give an opinion by accident, sorry. It's mine only.

I will read one recommendation. So I'm not going to give a recommendation, but I'll read a recommendation we've given to tell the story. So I'm going to try to tell a little story here. I was told to keep this high level. We might beep into the weeds a little bit. It's a Technical Conference after all. So with that, let's just start with the first slide.

I figured since we're getting it started here, something to look at would be fun. So we're going to start with why do we need Ride-through. Just to tell the story quickly, the GIFs here are from Texas A&M's kind of synthetic grid system. They do heat maps for voltage and frequency Ride-through. They present them with their kind of synthetic grid that they use at their facility or at their university. So this is just to kind of show, when there is a disturbance when something happens, it propagates around. If you look at the heat maps for frequency, it's not just one disturbance. It's moving all around, and it's really -- you can see the differences in what's happening, what deviations are happening based on location, based on the system they're at.

And this is just kind of the world we live with, right? Unexpected events, they happen. They're going to happen. They're going to continue to happen. Our job as an industry is to make sure that when they happen, we are -- we've done our homework, right? We've done it, we've done our planning, we've done our interconnection studies, we've done our modeling correctly.

Not every unexpected event is a major disturbance. You know, someone hitting a telephone pole -- or sorry -- utility pole and dropping a transformer is not going to cause a massive frequency deviation, but something like a -- an DESO-1 or DESO-2, we've seen, or a Uri, right? We've seen unexpected events cause significant deviations to the point that we have literal processes for tracking these things and reading these things and, again, reports out our disturbance reports.

So what do we do? We have to make sure that we reduce risk by making effective and efficient criteria. Efficient is kind of the -- I took this from our little circle. Efficient is the key thing here, right? We could probably make a system that is perfectly reliable, but that's going to be a tank when we might need a Toyota Camry, right? We can -- you know, there's always that kind of how much can you do with something that's reasonable or something that's efficient, and how do you hit your reliability with a certain level of risk averseness, which probably isn't a word, while still making sure that we're not making everyone pay thousands of dollars a month for their power bill.

So next slide, please, Levetra.

We'll start with just -- or I guess we'll continue with talking about what we've seen so far. Right now we have 10 published major disturbance reports since 2016. That's about 15,000 megawatts, and the last four years have been about 10,000 of those megawatts, so -- and about twice as many events. So if you look at two windows of time, we've doubled both size, total size, and we've doubled the frequency of these events, which means they're probably -- they're linked a little bit. The observations point to the fact that they're linked to penetration of IBR, right? If you look at the little graph on the bottom left, you can see the events, right? They're happening in areas that right now have some of the highest penetration of IBR. Major disturbances, those reports, those are -- those 10 reports are IBR related. There's been a few more of those since those last ones are out. We're in the RFI kind of data collection stage for those.

But that's not the whole story, right? There's also different technology. So the major events so far that we've given major event reports for have been solar PV and BES. That's not to say that they're the only folks that have problems, right? Most IBR technology's relatively similar outside of the hardware piece, right? There's software based, software driven, a lot of if I do something wrong parameterizing a PV, I probably make that same mistake, parameterizing a wind turbine in the software parameter sense, and we do have some data to back that up. NERC is working with Texas RE and ERCOT to make a wind report that shows and links to the causes of reduction of those previous disturbances. So that's to say that just because there hasn't been a major disturbance that was a wind -- I guess there was a panhandle disturbance, but there -- other than that, there haven't been that many wind-related disturbances.

It's not to say that the wind has no risk associated with it. Just preliminary, kind of off the top of my head numbers for that, it was something about 80 percent of the multiple thousands of megawatts unexpectedly tripping off wind in Texas, about 80 percent of those or 90 percent of those were for the exact same reasons that we presented in all of the solar PV and BES reports. So why are they not showing up? Well, they're kind of, you know, it could be at night, right? The faults happen during the day. Maybe wind isn't operating at full capacity like PV is. If I have a hundred-megawatt PV plant and a hundred-megawatt wind plant in the middle of the day, the wind plant's probably half-ish and the PV plant's at max.

So the same disturbance trips both of those off, same size plant, but the event for the PV is twice as big, right, because it's actually operating at max. So outside of those, we also have Winter Storms Uri and Elliot as far as, like, firm data we can pull from, and just those are the Uri and Elliot on the right side here. So if you go to the next slide, please.

All right. We'll orient ourselves with what I realized -- it's actually pretty clear. So we'll orient ourselves with what is out there right now, so, and what we're discussing today. So kind of I linked it to PRC-024, PRC-029, the draft criteria right now, and IEEE 2800, and they're all in the same graph here, and it's kind of a mess, right? Part of the mess is --

someone brought it up -- PRC-024 four has regional variances for -- different requirements for different areas, right? If you look at, you know, the draft PRC-029 and, you know Quebec's PRC-024 curve, they're pretty similar, but again, that's for a specific system with specific needs.

And also the mess of this, it's confusing, right? It's hard to look at that -- you know, if I'm -- if I'm interconnecting a facility, and I want to do it across the United States, and I want to be a developer, it's kind of confusing to know, you know, exactly where to find each criteria, exactly how to do each plant in each area and how we talk to each other. Reviewing the alert data, what we saw a lot of in ERCOT specifically was ERCOT machines have Western interconnection parameters, right, because they're similar developers, and they just put them on that one, right, because they're not the same. Unifying them can help, but there will always very likely need to be some sort of, you know, small variance or something to make sure that everything's reliable for everybody. There likely isn't any one-size-fits-all anything for everybody, but if you have a good starting point, we can adapt that to what we need for reliability. And what I did to kind of help with the rest of the slides and the comparison --

If you go to the next slide, Levetra --

I realize that's a typo. I wrote "most stringent," but it's least stringent. I took the inside of every curve to basically say if you were following the minimum or the least stringent PRC-024, that's what we're comparing the rest to. And when we talk about the events coming up, that's what we'll use to kind of use for a barometer. And it's much easier to look at these three curves versus, I think it was like nine on the last one.

So when you look at this kind of comparison, you'll see that -- a couple observations, right? Draft PRC-029 and IEEE 2800, they share the same continuous operation bands, so both of those standards are saying that for these bands of frequency, continuous operated. So that's an alignment that's good for the rest of the discussion after reading all the comments that we've gotten, but they deviate pretty significantly kind of specifically at the maximums in the short timeline.

So, I mean, if you look at kind of farther out in the 200-302nd range, we're not that far off. They're pretty well aligned. It's just this kind of first six seconds where we see the massive deviations both from 2800 and from the original PRC-024.

So if you go to the next slide, please, we can compare that to our major events.

So y'all stole my thunder a little bit here by doing your due diligence, which is great, but none of the major events -- none of the 10 major events we've released reports on were outside even the continuous operation bands. And if you look at the little -- the very small, very skinny yellow rectangle, that is the worst frequency deviation and time out of all of the events, and that's Blue Cut in 2016. And you can see that's well, well within both PRC-024, within the continuous operation bands, and it's well within both PRC 2800 -- or sorry -- IEEE 2800 and the draft PRC-029.

So this kind of shows us that for those types of events -- you know, keep in mind that these disturbance events happen somewhere around like system normal, right? So we might not see -- you know, we're not expecting to see a massive crazy change here. The system's about normal when these are happening. So what we get, because operators are doing their jobs well, because we have things to do and procedures to mitigate when these events happen, the deviations aren't that bad, at least from what we've observed. Things will change as we change penetration, but we'll have to assess the risks and how we get there and how we can kind of guess or study or estimate what they will need in the future. So this was system normal, major events. Again, this was the worst case. Very many of them were, you know, in the order of 10 to 30 seconds or something like that, so about the same rectangle shape but much, much smaller on the graph.

So all I have to say is that when we observe our major disturbances, we've got a little bit of leeway with everything proposed so far. So we're not like right up against anything at the moment, but all solutions seem to be viable as far as riding through the major event reports.

So if you go to something on the next slide, which is, you know, not system normal.

This Uri and Elliot. They're bigger, right? The rectangles are bigger. Elliot was, again, about the same-ish as the major disturbance reports. So the Blue Cut graph very skinny, not a very large deviation, somewhat long-ish. But the interesting thing is Uri, right?

So Uri, if you notice, it kind of kisses the purple curve there, and that corner of the purple curve is actually ERCOT's frequency Ride-through, so we were very close. I'd say folks are starting to put protection things directly on the curve, like we observed quite a bit of in the alert data. We were very, very, very close to seeing additional tripping because of frequency protection on the criteria, so, and if that would've happened, that would be the first time we've observed it.

The last slide -- you don't have to go back -- what the last slide said -- I said nearly all frequency-related tripping was due to mis-operate -- not mis-operations, but incorrectly set parameters, instantaneous measurements. None of those -- I wrote "nearly" on the slide to cover it, but none of those were based on criteria. You can see on the last graph, too, that they weren't anywhere close to the criteria.

So at this point in the past, right, the bounds, we haven't gotten close to the bounds of any of things that we're proposing now, except for 2024 in Uri, and Uri was a massive, massive event, right? So maybe we're at a point now with this data that, you know, we might know that we might need to improve upon PRC-024. What we do to improve on 24 comes from all the input we're going to get from our panelists, the OEMs and their capabilities from the system folks in what they want or need or desire, and what kind of information we need to show that, hey, I can't do this and I'm going to prove it to you or not, or what's sufficient proof, or how do we study things moving forward.

So all of this can hopefully -- I'm trying not to get into too many details. I want the panelists to tell us all the things from their mouths, different, from them. So this is just to show that if we look at our data, it's not a ticking time bomb. It's maybe a time bomb in construction, right? It's a -- it's not an immediate tomorrow problem, but it's maybe a something we should focus on moving forward. But again, both things we're proposing, or, you know, we're talking about through all the comments, the main topics we're talking about are 2800 and PRC-029. Both of those would have, you know, written through these events.

So if you go to the next slide, please.

Just to summarize, none of the events we analyzed were outside of the continuous operation bands. And the next bullet is something a little bit interesting, is that because of that, we have no benchmark event, right? When we did the GMD standard, they had -- you know, they say you make benchmark events. So think of an event or look at a past solar or flare event and see what's happened and use it as a basis for, you know, setting up your parameters. So we don't have a benchmark event, right? We've had disturbances. None of them are saying what you have right now is insufficient. So we don't have anything to base that on.

So, you know, say we had an event that was exactly the PRC-029 proposed curve, then that's great, right? We say, hey, we saw an event. We witnessed this event. Our bounds need to be outside of this event. So we all say online, well, the operators do their jobs and fix the system. We don't have that. We've also seen -- so with that, there's kind of three ways, right? It's a benchmark event, it's doing detailed studies into the future, or it's saying that give us the best you can do until we either hopefully never get a benchmark event or improve our study practices and data practices to have some meaningful forward-looking studies.

So looking at the data we're receiving in our Level 2 alerts, both modeling and IBR performance, and kind of the fact that none of the 15,000 megawatts that tripped offline were predicted in the model space, I don't know at the current moment if the industry's ready to say, hey, here's a study I'm going to hang my hat on that says here is the level of frequency Ride-through I can get my system to do and use it as a benchmark event, right? We need to improve our modeling, improve our studies, improve our parameterization, and then maybe we can trust that for something as important as setting these things.

So what you can do now is you have kind of two things. Either set your protection settings as wide as possible and show us that with data and not, like -- you know, show us that literally if you exceed this, you'll burn, right, or come offline or damage something, or come up somehow with some criteria that happens to be able to be accomplished by everybody, right? So at this point, those are the branching paths we take as far as, like, putting some data-driven decisions there, right? It's maximize --

And if you go to the next slide, please.

Maximize your settings or use those and feedback and that kind of stuff, just come up with bounds that are reasonable for everybody. Maybe some will be able to meet them, but if we have criteria where the number of folks who can't meet them is a number that we're happy with -- or not maybe happy with, but okay with, you know, operating the grid width, then we're moving the industry forward, right?

So this is a recommendation from our Level 2 alert on IBR performance issues, and I'll read this and then I'll tell you where it came from. And so, basically, what we're saying is expand your voltage protection setting as widely as possible and minimize AC instantaneous voltage dripping. So the instantaneous pieces of both of those bullets, there's language in the standard addressing those things. But again, frequency and voltage protection should be based on the equipment capability. We've been saying this in the alert. The reason why it's in the alert is that this is actually a recommendation that was in Blue Cut, the very first disturbance report. It's been a recommendation to expand as much as you can since the first event.

So it's very important to maximize your capabilities as you can because, otherwise, you know, you're leaving things on the table, right? It doesn't make any sense to, you know, have a certain frequency Ride-through or voltage Ride-through ability and then set your parameters, you know, 30 percent inside that curve, right? You're not helping anybody on the system for that. So that's why this recommendation is here.

This is the recommendation I was reading. It's published, so it's not my opinion, and, again, repeated in basically every disturbance report and the alerts. And it's not in the modeling alert, but it's been repeated, and it's kind of what we're saying is a good path moving forward.

So next slide, please.

So what do we do, right? You got to balance, right? There's balance between what the system needs to be safe and what you can do with the things that are out there on the system, right? If we combine those two into a -- the Venn diagram I made, hopefully, if you use technical capabilities to inform what you can do to meet bulk power system needs, then you get effective and efficient criteria, right? If the bulk power system says I need 80 hertz per 10 seconds, and the IBR says I can only do 75 hertz per 10 seconds -- I'm picking random numbers to not get close to anything we're talking about -- then you got a problem, right? And then you would ask, hey, how many of you folks can't meet this, and you get a number, and if that's the whole system, maybe that's not a good criteria. If it's 10 percent, maybe you can live with that, right?

So when we talk about bulk power system needs, what are they, right? Ride through things so that you can fix it, right? Stay online while the operators do their jobs and restore the system, and be effective and efficient when we're reducing risks. So that's all the things in 901 data, modeling studies, all that kind of stuff. Those are the bulk power system needs, very high level and in two bullets only, and then you have to compare those things to how do you get that, right? If I have a new criteria and I see you must meet this, how soon can you put something on my system that meets it, right?

That's something that OEMs will talk about, I'm sure, is the development cycle for products, right? Usually requirements inform design of IBR, right? We used to ask for requirements all the time when I was at the OEM, you know, please tell me what you want so I can build it and give it to you. The problem is that takes a while, right? And nd if you keep changing things, right, if we -- if every other year we have a new kind of proposed thing, then it gets kind of hard, right, to make sure we're designing things. And if you keep resetting the cycle every couple years, we're just kind of, you know, we're wasting money, you know, IBRs become more expensive, power becomes more expensive, and it's just kind of a big technical thing the OEMs will really probably correct me on and expand upon.

Next, we also have hardware limitations at legacy IBRs. We're going to hear all about that, I'm sure, from all the panelists. The fact of the matter is, some of it -- some of the IBRs won't be able to Ride-through any criteria, right? There are IBR out there on the system now that don't meet PRC-024. There are IBRs that don't meet PRC-028 -- or sorry -- PRC-029. There are IBR out there that don't meet IEEE 2800. So whenever you have a requirement, if you look backwards, there's always going to be some level of equipment that can't meet it, and what do you do about that is kind of the answers -- is one of the answers we're hoping to get from the folks who are talking here.

And the last bullet here is that you kind of get some diminishing returns, the capability extremes, and I kind of referenced it a little bit earlier, is if, you know, say we're all buying a car. The speed limit is 50. All the cars I can buy go 50, right? But then someone says, well, you have to have a car that can go a hundred miles an hour. I'm not going to buy a car that can go a hundred miles an hour if the speed limit is 50, right? So the products are going to be designed towards what about their requirements are, and if you really expand those to the bounds of equipment limitations, you know, it might be very expensive to get that last extra hertz, right, or extra hertz of criteria, an extra couple seconds of time.

So really, that goes back to the effective and efficient and reasonableness thing, right, is probably if we set some parameters very wide, in a few years after the development cycle, people could meet it, but what does that mean? Is that, like, a $10 million wind turbine now because, you know, it costs $2 million to get it to 63 hertz, but, you know, 68 might be some crazy amount of engineering or design and all that extra work. So the balance here is very important, and it starts with the needs. Basically, it starts with the needs, and then you have to balance it with what can I do and what can I do for some reasonable amount of, you know, effort, resources, that kind of thing.

Next slide, please.

So for new equipment, so I'm going to talk about new equipment, and then we'll go back to legacy stuff. So for new equipment, criteria need to be reasonable when compared to current and future capabilities. So if everybody's designed for one thing right now and we go 10X that, it might not be reasonable, right? If everything's been designed for something, when we change that criteria to expand it, we have to make sure that it's at a level of expansion that keeps the grid safe while also making sure that we're not putting -- we're not going to make things cost an extremely large amount of money, right, because we're trying to meet these future capabilities and that kind of stuff.

So if criteria are outside of equipment capabilities, like we're -- we know we've gotten some comments about from our written comment submittal, we need lead time, or the industry needs lead time, right? It takes time to build a new inverter. It takes time to do research and testing and all that type of stuff to be able to build something that you can sell to someone to install, and they'll still give me input, but probably five-ish years, you know, a ballpark.

And again, testing time, right? So you design it and you build it, and then you test it to make sure that it can do these things. There's not that many test systems in the world that can handle a, you know, a giant wind turbine or a full-sized inverter. So there's lines from major companies to test these things, so that also adds into the lead time necessary, right? You got to build it and you got to test it to show proof that you can do it, right? We're asking for proof of what you can do. You can't do that without testing it and showing you Ride-through.

So the bottom bullet is in red, and we're leading into the panel this afternoon, but input from manufacturers is crucial, right? Those are the folks who know what's in the box, right? They know what's in the box, they know how you got to what's in the box, and they know what's possible within the same box and what it means to build a brand new box, right? So their input is very crucial to kind of do the balancing act that we need to do for the efficiency part of that Venn diagram.

So next slide, please.

So for legacy equipment, we'll go very quick through this because I want to leave some time for questions, but there's a bunch of different things you can do. So the easiest thing, software-based protection change, or software tuning to make your Ride-through a little bit better. For those folks who had a 65-hertz capability and set their protection setting at 63, software change, right? Put it to your capability that's in your software. That is relatively cheap and relatively easy to do. It could be free, sometimes it might not be, but it's significantly cheaper than hardware based.

So hardware based has kind of two buckets, right? It could be small, hardware-based retrofits of equipment, maybe a new transformer, maybe something -- you know, a new smaller piece of equipment that's going to be more expensive than a software-based solution, but it's definitely going to be cheaper than repowering the whole plant, right? So that kind of nuance in the timeline of resources necessary from left to right, that's going to be very crucial to hear from OEMs, right? What is a small hardware based? What are your thoughts about doing that? Maybe the generator owners could answer that. What are you comfortable with? You know, at what point does a retrofit turn into a repower, right, and at which point does that mean you're not going to operate your facility anymore? Those are the types of balance and things that we need to hear from industry and from the OEMs to give us this information so the Drafting Team can update the language to make sense for all of us.

So again, I think this is the second of three times I wrote that. Manufacturer input is very critical, right? Diesel documentation, sharing the documentation, having it ready for folks to read and review, very important.

So next slide, please.

And this is my engineering slide. There's no pictures, and it's four bullets and, you know, four sub-bullets, five sub-bullets. Figured we'd want one big text wall for us. So are exemptions necessary?

I'm going to really leave this up to everyone else to talk about, and I would just keep it real high level. So we all know some amount of IBR may not be able to meet any of the proposed criteria or current criteria because they were installed before current criteria was made. Again, software-based upgrades could be a simple path -- simpler path. Additional considerations that are needed for software upgrades are not sufficient, so if I can't just set it back to whatever, what else can I do? How do we do it? We need to put for that. That's very important.

But the third bullet here is that exemptions could allow legacy equipment to remain connected while maximizing capabilities, but then there's like a giant burden of proof for that, right? It's going to take more than someone saying, my manufacturer said they can't, right, and they attested to this, right? That's probably not sufficient as far as documentation, right? We're looking for things like show us a curve that, you know, shows you're going to damage something. Give us documentation that your software-based protections aren't sufficient, right? New software can't go into old equipment maybe sometimes. Maybe it's firmware limited. Maybe they're already set at their maximum capability, right?

And then we need someone to be able to review these to assess risk and to basically see if they're true, right? If someone says, hey, I can't do that, and they won't give you any documentation, then it's hard for us to take that as, you know, a firm piece of validated data to make a massive decision, like changing Ride-through parameters for everybody. So what we can say, and I think this is pretty not contentious, is that, you know, blanket exemptions with nothing, right, blanket exemptions for everybody who asks for one is likely not as sufficient solution, right? So exemptions, if we get there, if the input leads us to that path, which they may or may not, they're going to have to come with some data to back it up.

So next slide, please

So we do have some data. The data is from the Level 2 alert for IBR performance. Keep in mind this was just solar PV and BES, and I realize that the numbers are super small. So the first piece of the data is that about 70 percent-ish of those folks who gave us their frequency protection settings said that they were not based at the maximum hardware capability. So we have reported data that says about 70 percent of the IBRs out there right now can do some sort of software-based something. Is that software based something big enough to meet PRC-029? The manufacturers will tell us. So we do have some room to make some adjustments.

What we also have is they gave us their protection settings for their inverters, and I didn't want to give, like, real megawatt values, but I put them in percentages. So this pie chart is all of the settings that were given to us where they said that they were at their maximum capability, and I'm going to walk up here and read it because I can't see.

So if you look at this thing, this is the -- all of them are within maximum capabilities, and we start with PRC-024, so this is the small blue chunk. Seven percent of what's been reported to us is within PRC-024, so current requirements, about seven percent are reported inside that. The next biggest chunk, about 32 percent of those inverter settings are within 2800, which means that, if the data is true, right, if the data they gave us is right, and they're at their maximum capabilities and that's what they're at, then we got about 30 percent of what's out there right now within 2800, which is somewhat actually in line with the data we got back from some of the folks who submitted that to us in writing with real numbers.

So the big chunk is things that are within PRC-029, right? Sixty-one percent of the total maximum are within PRC-029, and that makes sense, right? As you make the curves wider, fewer and fewer equipment are going to be able to meet it, right? So as you make things wider, we'll have to -- we're going to have to deal with a large number of potential hardware-based solutions. And what that number is and where we land in the spectrum of curves is going to be dependent on what we can do, what we're happy with not meeting criteria and what we do with those things.

So this is just to kind of quantify and to show that it's very important to pick the right, you know, criteria so that we don't end up with, you know, a circle that says a hundred percent of equipment can't meet it, right? We don't want that at all, but we got to pick -- the onus is on us the Drafting Team and as an industry to pick some criteria that we are happy with the things meeting and happy with the things that can't meet. And potentially, like we've discussed, you know, documenting limitations and providing that as evidence to be used for drafting decisions, right, and that kind of stuff.

So next slide, please.

I'm going to go very quickly so we have some questions time. So manufacturer challenges, they're going to talk about it in a moment or after lunch. So new IBR, what criteria to build for? How do you procure test locations? Long lead times. And again, at the extremes, right, the capabilities get really expensive, right? The extremes of anything get really expensive. For legacy equipment, hardware limitations, software solutions might not be sufficient, and legacy equipment was tested with applicable criteria in mind, right? So there's actually a decent number of stuff out there that we don't know what the -- we don't know what it can do because it was tested for PRC-024 or slightly more than PRC-024.

It's never been tested and it's likely that it's never going to get tested, right? You're not going to, you know, take down a wind turbine and drive it to Europe or maybe been a boat or a plane, right, and put it in a container and test it. So there's a lot of unknown there as well, and coordinating and implementing effective solutions is difficult, obviously, right? We're having this conference. This isn't -- has not been easy for any of us to kind of agree on and get a solution ironed out, so it's difficult for all of us.

Next slide, please.

So industry challenges: deciding which equipment will be needed to meet new requirements, getting evidence that equipment can or can't meet, communicating technical details to everybody. How do you do that, how do you post them, what are you posting, and that's for new equipment. For old equipment, how do you manage stuff that can't do it, right? How feasible is the software solution? How hard is it to get data? Apparently very hard. We learned through our two Level 2 alerts, both of which had the first ever extensions of deadline, it's hard to get data. And we were asking for things we're talking about today, protection settings, and we gave about 90 days, a hundred days for that, and we had difficulty getting protection settings in that time.

We've extended the deadline again, so we feel industry's pain. We know it's a thing. It's hard to get data. The data's really specific and really technical. If you ask the wrong question, you might get data that looks good, but it's wrong, right? So it's very difficult to communicate all of that forward between all of us and to get to a solution where probably no one's happy and then we'll know we did the right thing.

So next slide, please.

So key takeaways, another big red bullet at the bottom. I've said all this before, but manufacturer/industry input, extremely important to know what we can and can't do. We are recommending or we have recommended for eight years now to maximize your Ride-through capability. Documentation that's validated and accurate is difficult to obtain but will be critical moving forward.

Next slide. I think that's it. Great. And we have eight minutes for questions, but it's my birthday, Manish. Be nice.

(Laughter.)

MR. PATEL: Well, where is the party tonight then?

(Laughter.)

MR. SHATTUCK: We can talk later.

MR. PATEL: All right. So, Alex, great presentation. So couple of thoughts. You know, you compared PRC-024 with IEEE 2800. That is absolutely right thing to do. And then another thing we can actually do is actually compare PRC-006, which is under frequency load shed standard, and it requires transmission planner/planning coordinator to design in the frequency load shed programs, such that frequency does not go beyond certain thresholds, right? And as far as the generator Ride-through capability is just outside of those thresholds, we are good, unless --

there is a thought out there that, oh, wait a minute, in future we are going to allow transmission planner/planning coordinator to go beyond the thresholds in PRC-006 right now, right? So this is -- this is another data point that, okay, if the transmission planner and planning coordinator is never going to allow frequency to go beyond certain thresholds, then what's the point in requiring a Ride-through from a generator, right? Okay.

So then you presented hurricane -- not hurricane -- Winter Storm --

MR. SHATTUCK: Uri.

MR. PATEL: -- Uri, right?

MR. SHATTUCK: Mm-hmm.

MR. PATEL: So NERC's -- it's a good comparison. I just wanted to point out that that is actually not very appropriate because that event unfolded over many, many, many minutes, right? I think, if I remember right, 30 minutes or so.

MR. SHATTUCK: Mm-hmm.

MR. PATEL: And actually, NERC System Protection Control Working Group ended up writing a white paper saying, well, look, we cannot design PRC-024 or PRC-006, which is automatic under frequency load shed standard to something that happens over tens of minutes. Those two standards, 006 and 024, are for things happening in matter of seconds where operator has no time to blink, right? So anyhow, that was good comparison, but I think it's a little bit of apples and oranges.

So anyhow, going back to we have to look forward -- figure out a way -- for path forward, I think we could take an approach that is taken in PRC-024 and 006 that, you know, for certain regions, the requirements are a little bit more stringent than other regions, right? So when we wrote IEEE 2800, those who don't know, I was a vice chair. My middle name is 2800 nowadays. I get bad rap quite a bit.

(Laughter.)

MR. PATEL: And I'm also proud -- I'm also proud sometimes saying that, you know, we didn't know what is the right answer, so we flipped a coin five times and decided which way to go. But so when we wrote IEEE 2800, what we did was, well, we don't want to write a standard that is based on most stringent PRC-024, right? We wrote a standard that met two largest interconnections, assuming that for two other regions, there might be a reason to require slightly more Ride-through capability, and those two regions will write their own variance of it, right? So I think that's the option we could consider is can we take different Ride-through capability for different regions. I guess that was not a question, a comment. Thank you.

MR. SHATTUCK: Thanks, Manish. Yeah, there certainly is precedent for having different curves. It's in 024, and it is a possible solution to move forward.

MR. KAPPAGANTULA: Good morning. I understand I'm standing between everybody and lunch, so I'm just going to make a quick -- a quick comment on one of the slides that you had that talks about software changes are being a little bit cheaper than hardware changes. That that may be true, but just understand that software changes are not necessarily cheap.

MR. SHATTUCK: Mm-hmm.

MR. KAPPAGANTULA: As an example I could give you, just to make some software changes on one of our battery projects, we got a code of nearly a million dollars, right? And so when we're -- when we're talking about something is cheap, it's probably going to be relative --

MR. SHATTUCK: Mm-hmm.

MR. KAPPAGANTULA: -- very relative. So I just wanted to point that out that, you know, just because we're saying we can change software on some of these things, that it's going to be cheaper is not true. And then you also have to factor in the points that, you know, if you made a software change, you have to figure out how the rest of the equipment would react to that software change and if the rest of the equipment can actually support, you know, making that software change on just an inverter, for example, right? So I just wanted to make that clear and take into consideration when we're saying, hey, software is really cheap.

MR. SHATTUCK: Yeah.

MR. KAPPAGANTULA: The other piece also is when you're changing some parameters, that may not necessarily be a software change. So there's a lot that goes into it, so let's not uniformly say that the idea of, you know, we can make a few tweaks here in the software and that's going to just do the job. It's not true. That's what my technical experts are saying.

MR. SHATTUCK: Thanks. Yeah, everything was presented as relatives, right? And the OEMs will give us the details after lunch. I don't want to speak for those folks, but they'll give us probably some real --

MR. KAPPAGANTULA: No, I'm, I'm looking forward to that, so I would rather hear from them saying, hey, software is not cheap --

MR. SHATTUCK: Yeah.

MR. KAPPAGANTULA: -- than me just saying --

(Laughter.)

MR. KAPPAGANTULA: -- yeah, because you can tell us what you charge, too. I'd appreciate that.

(Laughter.)

MR. ROGERS: Yeah. So real quick question. You showed us the curves that had the, you know, frequency excursion events that we've witnessed within them and plotted, and we touched up against one of them. So that was, you know, the actual, you know, what we witnessed with the frequency. But another part of the -- you know, one of the contentious points of this is the rate of change of frequency.

MR. SHATTUCK: Mm-hmm.

MR. ROGERS: You know, we're looking at 5 hertz per second in the proposed language. What have we witnessed in these events as far as rate of change, of frequency that, you know, really drives to the need for that 5 hertz per second because, you know, that's one of the issues, especially with the legacy equipment. Rate of change of frequency wasn't even a design consideration. It's not that, you know, it's not set high enough or the parameter's wrong. It wasn't a thing. Whenever a lot of this stuff was built, you know, it just wasn't a consideration. So what are we looking at as far as an actual need based on the evidence for the rate of change of frequency, or is that even something that we have the evidence to speak to yet?

MR. SHATTUCK: Yeah, great question. I don't think I have that data. I don't think we have that recorded data. We have the frequency traces, but it's that, like, SCADA data granularity, right? So that's -- a specific data point we don't have at the moment. The only kind of information data points we have on ROCOF is -- that's rate of change of frequency for everyone else -- is, you know, international building standards or equipment standards that are used in a lot of IBR equipment facilities, right, the non-IBR pieces, the transformers, the other pieces of equipment. The data point we have for those are the, you know, the standardized ROCOF requirements, so, like, that's the only thing we really point to because we don't have the data from the actual events.

MS. CASUSCELLI: All right. I think we've got a hard stop, but maybe time for one online question. So software expansion study and accurate models are required. How will NERC support when standard models are required and when they are often not able to represent most IBRs?

MR. SHATTUCK: Great question, yeah. So I would -- I would like to point everyone to NERC's published that modeling guidance, which says that if you want to do something like a detailed study, right, an interconnection study, a study on your own facility to evaluate your design, for a local reliability study, if I'm Texas -- oh, that's a bad example -- that's a bad example -- if I'm New York studying New York, we are recommending user written models, equipment-specific, manufacturer-specific models, we're aware, right, obviously that many folks can't submit them. They're not allowed. But I would point also to FERC Order 2023, which says to submit both the standard library model and a user-defined model. And, you know, we totally recognize that if we're using a standard library model, we're not going to be able to represent most of these things we're talking about, specifically the detailed protections and that kind of stuff.

So we're recommending to use those more detailed models specifically for what was in the question, right? We know that what's out there is insufficient. Nothing's been captured, right? Nothing's been predicted, none of the major events. There is -- that's why we have a modeling alert out right now, right? The idea is to raise the floor of study work-through, you know, proper use of more detailed models where appropriate, not to say that standard library models have no place anywhere. But if you care about the result, if you want it to be accurate, if you want to be able to take that study and put it into a product or vice versa, you've got to use something more detailed like a -- usually a defined equipment-specific model.

MR. MAJUMDER: Rajat Majumder. Thank you so much, Alex. This is music to my ear, but I'll just make a very quick comment. You just said some people may not be able to provide that. The flip side is most of the major ISOs do not allow it. That's the -- that's the problem. I mean, manufacturers are on the -- on the room. They can tell. I haven't had much trouble working with any of the leading manufacturers not being able to provide the model. They can, but their hands are really tied with certain ISOs, and it's going to that direction. We have many problem trying to convince those ISOs that they should use the user-defined model, not rely on the generic model. So please be aware of that. It's not just from the OEM. It is the ISOs who are not allowing it to make that happen.

MR. SHATTUCK: Will do that.

MR. BENNETT: Okay. So it appears we've come to the end of our discussion for now, so, Alex, thank you.

MR. SHATTUCK: Thank you.

MR. BENNETT: Great presentation. Very informative.

(Applause.)

MR. BENNETT: So with that, we're here at noon Eastern Time. We're going to take a one-hour lunch break, so we'll be back at 1:00 Eastern. As for online questions/comments, if we did get them addressed right now, they are going into kind of an archive folder, and we'll circle back to them at another point of our Technical Conference over the next day or two. So they're not gone. They're not forgotten. We have them, and we'll bring them up as appropriate.

And with that, I think we'll take a break. Lunch is just around the corner, and we'll be back at 1:00.

(Luncheon recess.)

MR. BENNETT: Okay. So I'm showing 1:00 here, and it looks like we have most everybody back here in the room. So for our online participants, I think we're getting ready to start.

So this will be our first pan of panel discussion of the day on "OEM Perspectives on Voltage and Frequency Ride-through Criteria." So to walk us through that, we have Standards Committee member, Charlie Cook, from Duke Energy, as well as Alex from NERC here to help us through that. So with that, I'll turn it over to the panel.

(Sound checks.)

MR. COOK: Good afternoon. My name is Charlie Cook. As Todd said, I work for Duke Energy, but today I am here representing the Standards Committee. Alex?

MR. SHATTUCK: All right. My name is Alex Shattuck. I'll get my stopwatch ready for everybody because we're going to keep everyone on a two-minute time per question, so making sure we keep track.

So my name's Alex Shattuck from NERC. You heard from me just moments ago, and I guess we'll just jump right in if you want to ask -- get us started with the first question.

MR. COOK: Yeah. Could we have the panelists, starting down at that end, please introduce yourself? Tell us a little bit about yourself and who you represent today, again, keeping an amount -- I'm sorry -- keeping in mind that we are time limited, so.

MR. SCHMIDT GRAU: All right. My name is Thomas. I'm representing Vestas. I've been with Vestas close to 15 years, and I'm heading our Power Plant Solutions Group that covers everything from development, sales, construction, and service, and it includes every single topic related to grid interconnection and reliability.

MR. KARPIEL: Scott Karpiel, SMA America. Been in renewables for about 15 years with various different OEMs. Hope to bring kind of a broad spectrum of knowledge and expertise to the panel and the committees here today, and thank you for having me.

MR. KOERBER: Arne Koerber. I'm representing GE Vernova, and specifically the wind side of GE Vernova, and we also do other things. I lead the product line team for controls and software, and a lot of the discussion here today was around software and controls, so that's why I'm here. Been with GE 15-plus years in various roles around controls and software.

MR. DAHAL: Good afternoon, everyone. I'm Samir Dahal. I represent Siemens Gamesa on source side. I'm responsible for model integration, parameter rises, and for all our (inaudible).

MR. PATTABIRAMAN: Hi. My name is Dinish Pattabiraman. I'm a development engineer here at TMEIC Corporation, Americas. I work on modeling of our inverter-based resources, you know, meeting grid requirements for various ISOs, and analyzing grid events and finding solutions.

MR. COOK: Thank you. So the way we're going to do this today is I'm going to ask the first question directly to an individual, and then I'd like -- so I'd like the rest of the panels to pay attention and listen, and then if you have anything significant to add to what has been presented already, please do so. We'll give you each chance to comment.

So question one says, do you anticipate challenges with your equipment meeting the voltage Ride-through criteria as specified in Attachment 1 of the draft PRC-029, and there are three subparts to that. First of all being, if you do so, do you have an estimate for how many products will be affected? Second part, how does the estimate change when considering IEEE 2800? Third part, how does the estimate change when you consider PRC-024 boundaries? So I'll direct that question first to Dinish.

MR. PATTABIRAMAN: So for TMEIC inverters, especially inverters existing in the field, you know, we won't be able to meet IE 2800 at this point. For newer inverters, we'll be able to meet IE 2800 requirements. Coming down to PRC-024 requirements, most inverters in the field can meet PRC-024 requirements. Newer inverters, obviously, we'll also be able to meet it. But in terms of parameterization, we won't be able to eliminate parameterization for some older generation products.

For PRC-029, based on the language that is written, none of our inverters will be able to meet the requirements, especially given that there are requirements such as instantaneous or voltage protection should have at least one cycle of filtering. That's something that we wouldn't be able to meet even for all inverters.

MR. COOK: Starting down at the end, anything else to add, specifically, would you or would you not be able to meet the requirements?

MR. SCHMIDT GRAU: Repeat that one.

MR. COOK: Okay. It says, do you anticipate challenges with your equipment meeting the voltage Ride-through criteria --

MR. SCHMIDT GRAU: Yep.

MR. COOK: -- as specified in Attachment 1 of the draft PRC-029?

MR. SCHMIDT GRAU: No. Only for Type 1 and Type 2 turbines, which is very limited install base in U.S. And we do see end of life cycle in the near future and potentially be powered to different projects. For the Type 3/Type 4 turbines, we anticipate to meet the requirements for Ride-through requirements for PRC-029. Those requirements are also aligned with the new design philosophies and also with the IEEE 2800.

MR. COOK: Okay. Thank you. Next, please?

MR. KARPIEL: So future, current, previous generations of our inverter stations, I have no problems with the voltage Ride-through. The legacy stuff that's going back 10 or so years, clips a little bit of a corner on one of the Ride-through corners, but then with the exemption, it shouldn't be a problem.

MR. COOK: I'm Sorry. Could you clarify that about the exemption? What was that statement?

MR. KARPIEL: Well, does it not state for voltage that there's an exemption?

MR. COOK: Yes. Voltage, yes.

MR. KARPIEL: Yes.

MR. COOK: Okay. Just want to be clear. Next.

MR. KOERBER: Similar to my colleagues here, I think we have to really split this between new products that are under development and the installed base. For new products, plants are generally aligned with IEEE 2800, so we're evaluating what's the difference. What impact does that have for the installed base? We do expect that the majority of the installed base does not meet these voltage Ride-through curves. Some cases might be close. In some cases with a project-specific evaluation, voltage drops across the collector system, it might be possible to meet it, but on paper and curves taken strictly as stated, we do expect that the majority of the installed base does not meet those curves. That's on the curve.

And then it's important to point out that Attachment 1, Items 9 and 10 have additional requirements that weren't previously requirements. We've already had a quick discussion this morning on the instantaneous voltage and on multiple fault Ride-through, and we do expect both of those to be challenges for the installed base.

MR. COOK: Thank you.

MR. PATTABIRAMAN: Yeah. We have a similar comment as our colleagues with G. For legacy turbines, we can Ride-through the curves, just the curves, with software, unlimited hardware upgrade, but items listed in 9 and 10, multiple Ride-through instantaneous, that's not something that we've been tested and evaluated, so that would require a thorough investigation from our part. And the testing part, like it has been brought a couple of times, there is a possibility for legacy turbine to be retested against the newest standard is, I don't think that's going to happen.

MR. COOK: Okay.

MR. PATTABIRAMAN: We will have to ask for exemption on those.

MR. COOK: Thanks.

MR. PATTABIRAMAN: But for the new lines, we would completely design our product to comply with IEEE 2800.

MR. COOK: Thank you.

MR. SHATTUCK: So I guess most of us are wind, right, here. So we're missing our estimate participant, but I guess, Dinish, since you're the --

(Side conversation.)

MR. SHATTUCK: All right. So for y'all's perspective, like, what's the -- kind of similar responses with some varied, you know, actual numbers, but what are the main differences for kind of the failure to meet or challenges between wind and solar, you know, just the technologies as a whole themselves? Like, I guess what are the limiting elements when we say something can't meet one of the requirements? Is it -- is it a software? Is it a hardware? Is it old firmware? Is it a specific piece of equipment?

MR. KARPIEL: So for PV and BES, battery energy storage, it's both, right? There's a hardware limitation as to how long the holdup -- the backup for the communications and everything can withstand. So whether they're using a battery, a UPS, a super cap, or whatever they're using to have that buffer installed, so that's a hardware limit -- that could be a hardware limitation.

And the other one is parameterization, right, the software that's the firmware that's used in inverter technology. Amongst the experiences that I've had with the different OEMs and legacy products here at SMA is the firmware has a limitation of how far it will allow you to Ride-through in amplitude and time. That's usually set by some other kind of hardware limitations so you don't damage the equipment. So I can't speak necessarily for the wind side of things, but for the inverters, the PDs and better energy storage systems, it's a combination.

MR. SHATTUCK: Thank you.

MR. PATTABIRAMAN: Just to add to it, yeah, the same. It's pretty similar reasons. It's both software and hardware for at least the Ride-through curves by themselves. In terms of other requirements that are -- I think the gentleman from GE also brought this up before -- the instantaneous overvoltage protection, having one cycle of filtering is something our hardware cannot do. You know, IGBTs have very limited voltage handling capability, so having a one-cycle requirement significantly exceeds the capability of our products.

MR. SHATTUCK: Thank you.

MR. DAHAL: I would like that for wind especially. You have so many components inside the turbine, right, converter/inverter being able to do something doesn't necessarily mean the turbine can hold can do it. So for us, software limitation is there, and there is also hardware limitation. For us to be certain that just because converter can do it, you know, we are not going to be comfortable telling wind turbine as a whole can do it, right?

And also, when we are talking about software parameter parameterization, we cannot forget about the models, right? Every time the software gets parameterized or firmware get updated, corresponding model is expected to be provided, and rightfully so, right? For our legacy turbines that have been operating for 20 years and no longer in design phase, models were provided when they were first commissioned. I don't think anybody actually started using those models and providing feedback to us, so we saw no reason to update those models. Like, for the legacy turbine, we do not have any reason to keep them updated since we never got a feedback on a -- if there is any need to be updated. So all of a sudden asking not only to change the parameters, but also provide the model in a reasonable time -- updated model in a reasonable time that works with today's simulation environment, it's going to be a huge challenge. I mean, it can be done, but it's going to take a lot more than six month or a year.

We have -- we currently have closer to 15, 16,000 units installed, right? Each of those turbine might not have the same firmware. I know it. They don't, right? And also, our customers or the assets owner do have some flexibility on changing the parameter as they deem necessary, you know, based on their field experience or what have you. That information we do not have. So there is significant challenges just to provide a -- you know, to meet the new standard with those software or, you know, hardware parameterized, and I don't want anybody to forget that, you know? Yeah, you can -- we can do it. Parameterizing software can be done in, let's say, a year, but getting our corresponding model will take a lot more than that, yeah, especially validating as well.

MR. SHATTUCK: Thank you. The mic was off, but they said, especially validating those models, and I'll ask one more follow-up before we go to the next one. Sorry. Thomas, did you have something?

MR. SCHMIDT GRAU: Yep. No, and even if we have the models available, often that's -- to Rajat's comment earlier, ISOs and utilities don't allow those models to be used that is accurately representing studies for the -- evaluating PSE, so that's one of the challenges. We have -- we, to some extent, can do software upgrades and pure parameters with our software, but we are not able to do the evaluation of what parameters are required for that specific site because the utilities often don't allow us to use the right models for that evaluation.

MR. SHATTUCK: Thank you, and I'll ask, I think, the last question. The end of this might be a little faster, so we'll dig into some details here. One more detail question. So we talked about kind of the inverter/converter in the turbine in the -- in the inverter. What about balance of plant equipment? So this is a -- you know, it's a resource standard, right? The IBR must ride through, so are there challenges in balance of plant equipment as well?

MR. SCHMIDT GRAU: Yes. So if we look at the frequency response, that's where -- there's no design standards as we are aware of, that designs for plus/minus 4 hertz per six seconds. So you will see cooling systems and substations be affected. You have all the different equipment and the turbines being affected. It's not about the inverter. Inverters have some flexibility, but we cannot forget all the auxiliary component sensors, cooling systems, relays, protections, transformers, that is not designed for plus/minus 4 hertz per six seconds.

MR. KARPIEL: And let's not forget the medium voltage transformer that comes with the inverter station. Those situations that have high voltage and low frequency, you'll put your magnetics in the saturation, right? Saturation causes heat. Heat causes breakdown. So we have to be looking at the whole picture, the entire balance of plant to ensure that the inverter-based resource unit -- I know there's a lot of talk about what that definition is, but the station itself needs to be able to ride through 299 seconds, 660 seconds of this voltage or that frequency. And it has to be looked at by the OEMs going back throughout all the legacy, all the generations of their product, not just the current and future. So there's going to be some gaps that are going to happen in the technology.

MR. DAHAL: I also want to bring attention to the concept of repower, right? Like, we're talking about this and talking about repower. The repower that we've seen so far have been efficiency driven, right? So repower happens because you want to get more power out of the old turbine, not necessarily the electrical -- new set of electrical performance. We retain the main brain converter/inverter system, cooling system as it is, just change the rotor from the wind side. So just the term, "repowering," doesn't mean what you guys are thinking about repowering, you know. Oh, you repower, you get new set of performances from them, and that's not true at all. The market is not there for that to happen. The repower project that we have done so far has been purely mechanical repower, and it is very essential to consider that as well.

MR. SHATTUCK: Thanks. Is that the same for solar?

MR. SCHMIDT GRAU: Oh, sorry. Maybe also to add to that, even if you do a full repower in a cell and hub from one OEM to another, it's often older technology that gets installed because the tower, the foundation, and structure is not built for the latest rotor sizes in inverters, so that even if you are able to fully repower, it's still going to be legacy equipment that's going to be repowered.

MR. PATTABIRAMAN: Just answering the question on the balance of plant equipment. There are surge registers that are also included in the design of a typical IBR plant. They're typically located at the end of a feeder through wide overvoltages, absorb overvoltages, and so on. And the problem is that these sites are already designed with certain energy levels for these protectors and surge protectors, and any level of higher overvoltage could physically damage these protectors. But that kind of also includes instantaneous overvoltage, like I said earlier, is that, you know, having a one-cycle delay could basically be the difference between damaging and not damaging these arresters.

MR. SHATTUCK: Thank you. All right. I think it's time to move on to our next question, which is the same question, but for frequency but just one tiny piece to add in is we mentioned transformer saturation. There's other things that happen when the transformer saturates, like harmonics or SSR, which aren't necessarily this specific Ride-through, but they're not particularly good, friendly phenomenon, so causing that saturation somehow is not always great for the BPS as well.

So we'll jump into the next question. Again, it's the same question but frequency. So we'll ask it to Arne, and we'll go down the line, but do you anticipate any challenges with your equipment meeting the frequency rate through criteria, as specified in Attachment 2 of Draft PRC-029, and then the same kind of sub-bullets, yeah, estimates for how many products for 029 and 2800 and PRC-024? So we'll go with Arne first and go down the line, yeah.

MR. KOERBER: Yeah. And for us, there's about -- preliminary analysis looking into this, we estimate there's about 20 gigawatt of installed capacity. These are some of the oldest units, substantially before 2014. That would not meet the frequency Ride-through requirement if comparing against the S-design curve. What it would take, not in a position to comment on this. It's about 20 gigawatts installed capacity, and the answer really doesn't change whether it's IEEE 2800 or PRC-024.

MR. SHATTUCK: And that's for legacy. It's all -- that's all --

MR. KOERBER: Yeah, legacy.

MR. SHATTUCK: We'll go down the line. Same path forward, yeah.

MR. KARPIEL: So for SMA, the frequency Ride-through requirements are not an issue for our inverters as well as our inverter stations and the magnetics that are on the unit, and that's going back to all -- even our legacy equipment, and it doesn't change, right? The frequency curve for 029 is larger than the 2800 or the 024, so if we can meet 029, we can meet the rest.

MR. SCHMIDT GRAU: I might've jumped the gun a little earlier before, but, on the frequency. But for Vestas, we cannot meet the frequency plus/minus 4 hertz per six seconds on our legacy turbines, and that's the installed fleet in U.S., I think around 15,000 units. And it's not in design consideration for any new products, and that's simply coming due to ancillary equipment in the turbine. There's no design process standardization for any, like, sensors, transformers, relays today that is meeting that. It will also potentially have cascading effect causing reliability issues if you have a frequency that is plus-4 hertz, minus-4 hertz for that long duration of other loads and things in the grid going offline. So we don't have it into consideration of design as there's no suppliers in the industry that can meet that today.

MR. SHATTUCK: And sorry. You said 15,000 units. Do you have a megawatt estimate for folks?

MR. SCHMIDT GRAU: I will find it.

MR. SHATTUCK: Okay. Thank you.

MR. DAHAL: I second Vesta's response to that. Our legacy turbines cannot meet PRC-029. We have not considered PRC-029, those curve for six second in our new design either. So as of today, we have no product that will meet -- that will comply with PRC-029 frequency Ride-through in its entirety. Regarding IEEE 2800, we meet our newer turbine and our legacy turbine with some software and hardware modification, mainly software. We will be able to meet IEEE 2800.

MR. SHATTUCK: With all legacy or with all your legacy equipment?

MR. DAHAL: Except for Type 1 and Type 2.

MR. SHATTUCK: Okay. Yeah.

MR. DAHAL: Type 2 and Type 4, yes. And then our restrictions comes from -- for whatever was mentioned already. We do not have motors that we can source that will be able to Ride-through all the ancillary equipment, you know. I think if you look at what other IEC requirement, IEC 60034, IEEE 50-1, they all have plus-3/minus-5 requirement for these motors, and that's what -- you know, that is in line with IEEE 2800, and that's what our design philosophy is. And let me also add our -- it'll probably come later, but design cycle -- design-to-market cycle is five years for wind turbine. So any new standard that has that much of an effect needs to be given at least five years, if not more time, to be applicable. And if it's, you know, cost prohibitive or anything like that, then that's going to be another issue.

MR. SHATTUCK: Thanks.

MR. PATTABIRAMAN: So for older TMEIC inverters, especially thousand-word inverters and before, we have hardware limitations in terms of what can be done in the order. So the typical design that was used was plus or minus 3 hertz. During the time, 5 percent change in frequency was the maximum capability of the equipment. So we may have hardware limitations, such as, like OX equipment, fans, or whatnot for cooling may have some hardware limitations. We are still exploring that. But even on the software side requirements, like, having 5 hertz per second were not part of the design criteria back then, and it would require a significant change in software to achieve 5 hertz per second. It's not a simple parameter change that it could do or a simple software update. There's extensive design.

And especially for our older inverters, we have limitations in our control board that would prevent us from downloading new software onto it, or like with excessive new capabilities, so they would require hardware changes to even get some of these software fixes. So they would require a new control board, maybe a retrofit kit for some of these existing inverters and an entire development cycle dedicated to developing new firmware for a new control environment or a development environment, so that would take a significant amount of time and resources. It would probably be less expensive to just repower some of these older inverters with newer inverters.

For newer inverters, yes, they have wider capability to meet some of these wider frequency requirements. But we still -- not from OEM perspective, but from a power system perspective, we still don't see the need to have these wide requirements, especially given that none of the existing events or none of the existing studies have pointed to any evidence of wider frequency requirements.

MR. SHATTUCK: Thank you. We'll move on to our next question. Oh, Thomas, go ahead.

MR. SCHMIDT GRAU: Forty gigawatt.

MR. SHATTUCK: Forty gigawatts? Okay. Thank you. Yeah.

MR. COOK: Jamie, do we have these comments captured, the responses captured from all of the panelists in writing?

MS. CALDERON: Yes.

MR. SHATTUCK: We have someone recording, and then we also -- most of them submitted these comments in writing prior to this.

MS. CALDERON: Yeah. There was one or two, I think, we were waiting on, but --

MR. SHATTUCK: We got them, I think.

MR. COOK: Okay. Yeah, that's what I thought. I looked, and I didn't find them all. So if you haven't provided comments, written responses to these questions, please do so. There's a lot of complicated numbers and stuff going back and forth. We have a court reporter somewhere, but she may be -- are you getting all this?

COURT REPORTER: (Off mic comment.)

MR. COOK: God bless you.

(Laughter.)

MR. COOK: Okay. Thank you. Next question, Question Number 3: what documentation is necessary from manufacturers to -- I'm sorry -- to prove which hardware limitations exist that would prevent your equipment from meeting the criteria in Draft PRC-029, Attachments 1 and Attachment 2? Go ahead. Yeah.

MR. KARPIEL: There would have to be some kind of a declaration, obviously, from the manufacturer stating that you don't meet this requirement or that requirement due to this hardware limitation, this software limitation. We're not going to share our IP, obviously, but we do need to provide indication of what portion of the standard that it's not going to meet, why it's not going to meet that rather -- if that's -- this unit doesn't have enough buffer in that -- the buffer doesn't have enough energy to Ride-through zero volts for X seconds, this is why there's no space available to install a UPS or something of that nature. It's going to be basically our responsibility to put together a declaration, like I said, and with examples, curves, graphs pointing to certain specific hardware components that are not available for -- because they're not available on the market to provide back to the GOs and then back to the TOs.

MR. COOK: And how would you envision that being presented as like this -- here's all the model numbers, here's what they can and can't do, and issue that generically or based on requests from a specific generator owner?

MR. KARPIEL: We would probably do it on a specific request because the inverters themselves have different hardware configurations. We'd have to go look at that specific project's build to understand what is or is not included in that machine and what generation it is so that we can accurately provide detailed information regarding the equipment that's in that plant.

MR. COOK: Thank you. Just pass it over to your left.

MR. SCHMIDT GRAU: Oh, we echo that as well. I think for frequency, it has to be a declaration. There's a lot of things that cannot be studied in any study world on it, specifically of all the auxiliary equipment, and in the turbine there's also all the rotating part -- motors, your motors, et cetera.

For voltage evaluation at planned -- sorry -- point of interconnect, I think it's really important, again, come back to the OEMs are required to provide adequate models and also that the industry is allowing to use them because then you can do the proper evaluation. That's both for legacy and also future. We look at these graphs and they're very static on a PowerPoint, but the voltage will dynamically change based on your current injection profiles, your site-specific tuning, your nearby generation, so it's not enough just with the document. We also need to do the adequate design analysis for it.

MR. KOERBER: Just to add what was said, especially for wind turbines, these Ride-through capabilities are really complex system-level interactions. It's often not there's one voltage that goes above the one limit, that this one component limits. It's many auxiliaries, many systems that interact on Type 3 wind turbines, these interactions with the hardware side, the loading side, and it's not as simple as here's the one limit. And proving that something can't be done in a system that involves multiple software systems, it's actually really hard. Like, how can we as a manufacturer of equipment and then say, this can't be done, we don't know how to do it. That's a very hard thing for -- to attest to, right?

We will provide the capability of the turbine. This is what the turbine can do. Here's the testing. Here's the evidence that we have. But showing that something can't be done, it's a risk, but also it involves opening up our entire design process. What are our design limits? What are our margins? There's a lot of IP involved, and we don't see us being in a good position to provide documentation on capabilities, on limitations beyond what's the stated, published product-level capability. It's speculation, and it's a very unbounded problem. There's a lot of things you can do with modern software -- modern software systems if you had all the time and all of the funding in the world to solve this problem.

So declaring this can't be done, maybe for some small sub-problems, it can be done, but generally, we see significant challenges, not technical challenges, but just how we -- how we handle providing this documentation. What can we actually sign up to say this is impossible, and what happens if someone does it? What happens if we are wrong when we declared this can't be done?

MR. DAHAL: Yeah, I completely second that, and I would like to add that each turbine needs to be evaluated on its own. We will not be able to provide a -- forget about the fleet level, right? We have 20 models so far with various power-rated power output from them. So we won't be able to provide, let's say, 20 different statements saying our -- this fleet can do this. It has to be per turbine based, as has been indicated, seeing what is inside the turbine, what component was resourced, and what kind of documentation we ourselves have that can be used to provide you all with what you need. So that exercise, again, will be very timely. You know it will take time.

And also, I'd also like to highlight the fact that just because, let's say, converter can do it doesn't mean the turbine can do it. Again, I'd like to highlight that because every change in the parameter requires load and control analysis to see if tower can sustain if there is enough vibration, if there is enough harmonic generated. And all that study needs to be done for every change in parameter when it comes to frequency and voltage, and that exercise is very time consuming as well. And for legacy units, I mean, that won't be able -- we won't be able to do that either, you know. So there is a lot of nuance than just saying, oh, it's a simple software upgrade, then you'll be able to do it. That's not the case.

MR. COOK: Thank you.

MR. PATTABIRAMAN: Generally, I agree with most of what was said, would be able to provide some documentation on capabilities that are already published. But in terms of new capabilities, we would have to undergo investigation, and we would probably provide a document on our company letterhead signed by the appropriate officer on the capabilities of the equipment.

MR. SHATTUCK: Go ahead.

MR. KARPIEL: So a comment. The five of us up here are employed by highly successful OEMs. There has to be a consideration taken for those OEMs that haven't been so successful.

MR. SHATTUCK: Thank you, and I guess the next question bled into this one, but -- and we'll start from Thomas and come back down the line. But I guess a follow-on to that last question is -- and I think the answer is -- y'all touched on it, but, you know, what documentation are y'all comfortable with sharing, right, with someone like the -- a transmission planner or NERC or, you know, your utility or entity, because it sounds like there's a clash of IP and sharing information, right? But we also have to make sure that BPS is reliable, right? So there's got to be some maybe middle ground of IP and/or justification or something we can all be comfortable with on both sides, but I'm interested to hear what y'all are comfortable with and what that might look like. Yeah, Thomas.

MR. SCHMIDT GRAU: Yeah. I think a lot of it was said already on that part, but to reemphasize, I think all OEMs, at least I can speak investors here, we provide some kind of general description and specification that we stand within, and all third-party components we source has to comply with that. Some might be slightly better, some might not meet -- will just meet the specification on it, so I think that documentation is key to keep and also to trust. There might be declarations, like rate of change of frequency, that you cannot simulate, where you have to have some declaration, where we have to look at site measurement, where we have to do some attestations around that. I think that also aligns with some of the FERC orders.

And then I will go back to the modeling again. We see the recommendation for EMT models, detailed models. They will most likely or they have to live up to those specifications and then trust that and implement that in the study phase to get a more detailed instead of looking at paper, basically.

MR. KARPIEL: Yeah, I agree with you a hundred percent. Without an NDA in place, it's a fine line of what the OEMs are going to be willing to share publicly and openly, so, but we're going to have to find that line and provide enough information that a decision can be made.

MR. KOERBER: Yeah, very similar comments. We're generally comfortable sharing existing product capabilities. This also includes existing optional features that operators may or may not have used and implemented on their turbines. This is fully-designed capability, product specifications, comfortable sharing this. We also have very consistently provided, let's say, indicated fleet demographics as part of NOGRR245 for ERCOT. How many turbines are impacted by what curve? And we generally plan to do so to help you kind of run scenarios. What's the impact? What would happen if we do that, generally reasonably, and we plan to continue doing that.

We really ask for an understanding, is that we -- like, it's very hard for us to publicly commit on capabilities that haven't been developed yet. It's just not solid practice because we don't know what issues we will encounter. The only way of doing it is sharing IP, so that's where we see the biggest challenge is on kind of speculating for the future, informed speculation, but --

MR. DAHAL: I agree. I completely agree with that. Our customers should already have, like, whatever VRT set points, you know, FRT set points, all the curve, all the reactive power capability document, all the simultaneities that we call for (inaudible). You know, if the frequency varies more than one person, you will need to sacrifice active or reactive power or both. All those documentation, they should already have it, and we regularly provide that.

Like, when it comes to unit model validation like ERCOT requires for the new project, we provide the report to go with those as well. But any standard needs to adequately address what kind of test needs to be completed, in what manner, in what setting, with what margin, and what kind of report are they expecting at the end of the day. But it can't be open-ended and ask us to, you know, provide all the -- all the, you know, documentation when there is -- the requirement is so vague. And obviously we can't speculate on the future requirement. Nothing gets designed anticipating the future needs. You kind of touch bases whenever it's designed.

During the first year of the design is where we reach out to our customer and everybody and say tell me your requirement, right? And then after second year, that practice is closed, and we are solely focused on designing whatever the feedback we got. So you cannot retroactively, like, for the ROCOF of 5 hertz per second, even if we have the product right now, there is no way for us to go back for the product that we are currently entering the design phase to implement that. We are already too late on that. We need to keep that in mind as well.

MR. SHATTUCK: Thank you.
MR. PATTABIRAMAN: Very similar comments. The documentation we can share is often based on our judgment internally and what the capabilities of the inverter are. Even with an NDA, the information we share is often very limited because of IP issues. So yeah, that's essentially what we can share.
MR. SHATTUCK: Thank you. Before we go to the next question, maybe suggest that the other panels, we kind of hit on this topic and kind of understand the other side of what would -- what they would be comfortable with -- well, whoever they're representing would be comfortable with getting, and, like, you know, feelings on NDAs and all that kind of stuff and process. So, like, we heard you, all sides, and now maybe next panel we can hear from what we're comfortable with as evidence, and maybe we'll meet in the middle. We can go to the next question now.
MR. SCHMIDT GRAU: Sorry. Maybe quick comments on the evaluation. I think that's really key for this as well because we have seen a lot of this evaluation for it done in the past with PRC-024. People basically

take our specification and plot the curves on top in Excel of the -- of the curve and say, oh, we're compliant or not compliant. That's so far from the truth, and I think that's also why we see some of these requirements, to some extent, go overboard on capability because we might not understand what is truly needed. And I think we as OEMs also have the obligation to help providing guide with that adequate information so we can understand the limitations of the equipment. And, yeah, it's a great step to talk about it today, but I think that's really important as part of the documentation is how to evaluate it, if you're compliant or not. If that's not specified and clear, understand that, we won't know what to provide.

MR. SHATTUCK: Thank you.

MR. COOK: Next question, Question 5, what is the generalized length of time associated with any design of current products to meet the criteria specified in PRC-029 without exception?

MR. KARPIEL: So we had one number here as five years. It could also last longer. I also think it's important to understand is it economical to redesign a complete turbine. If we have designed a turbine today and it'll be installed five to 10 years from now, if that platform gets completely obsoleted and we cannot sell it, where does the investment money come to redesign? So we're going to hit a race that we cannot comply with, that every time we have a new standard, we have to obsolete the old turbines. So it's really important for us that we also get some money back to keep investing and improve the products so we don't go into that race for it. So five years and maybe killing the platforms if the standards go in this direction.

MR. KARPIEL: So I've been in manufacturing a long time, and you have to understand that we're all lean manufacturers, not only from a manufacturing supply chain standpoint, but also a resource standpoint. We have a roadmap, and our resources are currently booked up for the next couple of years, if not more, going -- looking at next-generation products, operations, you know, the sustaining engineering that happens on the existing equipment, future generations, new designs. And then if we have to introduce something new, where does that go in the schedule? You've got design, you've got testing, you've got model validation and certification that has to happen, so minimum five to six years on a new design.

MR. KOERBER: And this is going to be a classical "it depends" answer, I think, for just new designs, turbines that are being designed, can they meet all these standards? Some of the numbers that have been mentioned here by my colleagues up here seem reasonable. That's about the right order of magnitude. We generally foresee the biggest challenge for products that are not no longer being manufactured, and when we internally evaluate it, what would a retrofit take? What does it take? We very quickly jumped to internal reasons. We no longer have a prototype. We no longer have a lab. Some of the simulation tools are no longer around.

But it's really not just the internal reasons. They are -- that's on us to overcome. It's a question of investment, and it's also external reasons. And on one hand, let's say, supplier relationships for products that we no longer manufacture, we may not be in business anymore with the suppliers of those subcomponents, which also have software, which have firmware, which we have to reactivate, which just like you are asking us the questions, what it takes, they will come back to us and say, hey, if there's no business, if you don't need to do a retrofit, we are not supplying to you actively anymore because we're not shipping those products anymore. It's just a whole supply chain that may have to get rebuilt up to even work through the engineering.

And then the second external kind of reason that makes this difficult is in our relationship with customers. We manufacture these turbines. We don't, in many cases, operate them. They've been operating 10, 15 years. Self-performing customers, they have their own services teams. They have -- may have retrofit those turbines. They may have replaced electronics. They may have replaced actuators. We don't know what state they're in, and they will ask us to guarantee that they meet the Ride-through performance if we do a -- if we do a retrofit. They will also want a warranty that whatever new software, whatever new component we install actually works and doesn't impact the rest of the turbine, as I mentioned, complex mechanical, electrical software system.

And then we won't -- we'll have trouble signing up for this without individually turbine-by-turbine, project-by-project, surveying and almost custom designing a solution for an asset that's been running for 15 years. All of this can be overcome, but that's why it's hard to give a timeline and talk about maybe the economics of what it takes to design a retrofit package for a product that no longer ships. And that's where the -- a lot of the uncertainty is coming from. Internal reasons, labs, all of this, it's one thing. It's the supplier and the customer relationships that come on top of it that make this fairly difficult and not very practical.

MR. DAHAL: I'd also like to highlight the fact that turbines today has not been like -- you know, we do not design a new product every five years, right? There've been accumulation of the experiences gathered throughout 15, 20 years, right, what worked in year one, what didn't work. We base the design on those components, like our experience, what failed on the field, what do we need to improve. So we are very excited to participate in IEEE 2800 and very static, you know, when it was approved.

Now, for OEM, it's, like, there's now one standard that we can design it for and maybe sustain it for relatively longer period of time without having to design to very specific market and have 10 different variation of the product. And now deviating from that just creates that, you know. We have to now face a decision: does it make sense for us to create a new product just to kill it in five years, and what does it mean by killing it? Then you are not getting any modeling support. If you have any issue on the field, good luck. I mean, we're -- like, that's what we are talking about, killing the platform. That's what it means. And looks like whole industry is kind of shifting toward like grid forming/grid following.

So I guess everybody needs to sit and think, like, what is the benefit that we're going to achieve? Like, is it worth it for OEM to force them to push back on getting, like, one percent of the capability more versus letting them invest on R&D to come up with new next generation of product, right? So that's also something to keep in mind.

MR. PATTABIRAMAN: So I agree with most of the answers said by other OEMs. In terms of timelines, if we start working on it right now, maybe it'll take three years to five years, design retrofit packages, design software in a completely new development environment, create all these packages for our customers. But the other important point is, you know, we also have a roadmap, what we are going to comply with in the next two, three years. And we see 2800 being significantly adopted, and our team is working on those requirements right now. We have a product pipeline. We have development resources assigned and whatnot.

So what I think these legacy requirements and retrofitting old equipment with new technology is going to do is kind of push out compliance for these newer sites coming in to maybe three further years down the line, you know, which is going to cause even more problems because there are more new resources coming online than there are legacy resources already out there. So not just does it delay existing products or, you know, not just does it delay implementation for legacy, but it also delays existing or new products under development.

MR. SHATTUCK: Thank you. We have one more question before we go to online questions, but I think most of it -- most of y'all have already touched on it briefly, so if you could maybe keep them to like 30-second answers, do rapid-fire summary of your already stated responses.

So the last question is, and we'll start with Thomas at the end, is, for currently in-design or, you know, future considerations -- or future considered products -- that's not good grammar -- are any of those able to meet PRC-029 criteria? So currently designed -- products that are currently in design or planned to be designed on your roadmaps, like we talked about, that would meet PRC-029.

MR. SCHMIDT GRAU: Yep. When I speak today and also talk about it, the PRC-029, I'm solely talking about the 4 hertz per six seconds. We are largely very, very supportive of the standard, but that specific requirement is depending on so many sub-manufacturers, redesign of the cells, different equipments, relays, that there is currently no product available with it. We can't retrofit any legacy turbines for it, and there is no product in design for future to meet plus/minus 4 hertz per six seconds.

So that is the limiting factor for Vestas. Again, just want to emphasize that we're greatly supportive of the PRC-029, but that specific requirement will require complete new platform. It will not go into our offshore market, it cannot go into the onshore market either, and there's no design for it.

MR. KARPIEL: Fortunate for us, there's no -- we're already meeting the requirements. All current and future products will as well. What I would like to say, as you can tell, that not all inverters and inverter stations are created equal, especially the legacy equipment that's out there.

MR. KOERBER: Generally, all our new product designs are aligned with 2800, so we're evaluating what it takes. As I've mentioned, several of us, including me, several times, the big concern is around the legacy fleet, not new units. Generally, design power generation equipment, meeting grid codes is a key part of it. There's some specific technical requirements in PRC-029. Some of them were mentioned. Some of them were mentioned in our comments. The one we haven't talked a lot about here that we do see as requiring a bit of a realignment on our side would be multiple fault Ride-through, going from two events to four events in 029, in general aligned to 2800, evaluating what it would take to realign. The stronger concern and most of the comments are really around the legacy fleet, not new developments.

MR. DAHAL: I completely agree. Our newer products will comply with 2800, but we do not have -- we haven't considered this 64-hertz-per-6-second criteria in any of our currently-being-designed product, so not the new one. We haven't considered that, and I don't think just a -- preliminary analysis doesn't allow us to be able to meet it just because of all the auxiliary motors that are in the turbines. And, you know, we are not going to get any assurance from our vendor that their motor would be able to Ride-through those. So we don't -- we have no product.

MR. SHATTUCK: Thank you. Dinish?

MR. PATTABIRAMAN: So for products in development in the future, we'll be able to meet 2800. That's in our planned roadmap, but there are at least a few constraints with PRC-029, which limit us from meeting it. Some of these were mentioned before. You know, one of the examples is one-cycle filtering for instantaneous overvoltages, which we won't be able to meet. I heard somebody mention that, oh, greater than 1.8 per unit, you know, there's not overvoltage going to occur on the grid side, but things could happen internal to the plant, which could trigger that kind of overvoltage. There could be a resonance condition. There could be a failure of one of the components that could cause a severe overvoltage. There are extensive studies done, called temporary overvoltage studies, to determine how much energy a surge arrestor can handle and so on. So the various constraints would limit us from, you know, achieving this one-cycle filtering for instantaneous overvoltages, including inverter protection, inverter components, OX components within the inverter.

The other constraint I see being a challenge is the 25-degree phase-jump requirement. The 25-degree phase-jump requirement is also there in 2800, but there is additional wording added here in the PRC-029 language, which states 25-degree phase jump initiated by a non-fault event, this is allowed to trip. No other kind of phase jump is allowed to trip, which is something -- which is the first from 2800. Also, it creates complications because the exception only states for phase jumps created by a non-fault event. A lot of fault events are actually going to create phase jumps, you know. The inverters really cannot distinguish between non-fault-initiated or fault-initiated phase jumps.

Significant phase jumps. So essentially, the language states that if there is a fault event causing a significant phase jump, like a 90-degree phase jump, the plant is supposed to Ride-through. But that is something that we cannot really ensure, you know, the significant phase jump is going to instantaneously cause the current to jump significantly high and trip the plant. So these are the differences -- the key differences between 2800 and PRC-029, which pose challenges. That's why I mentioned earlier and why the differences between 2800 and PRC-029 when 2800 has been discussed extensively, approved widely by a lot of people, and there's also test procedures coming in with 2800.2.

MR. SHATTUCK: Thank you. I think at this time we have 10 minutes for Slido questions or questions from the room. We'll let Howard go first. You've already asked a couple, so Howard, you go ahead.

MR. GUGEL: Thanks. Howard Gugel, NERC. So I've heard a comment a couple of times today that is a parity issue for me because it's different from what I've heard in the past. So I'm hearing that you as OEMs have accurate models that you've tried to provide to the ISOs and utilities, and they refuse to allow those models to be used. When we talk to ISOs and utilities, they say we can't get accurate models because the OEMs refuse to provide them because it's IP. I don't -- what's the right answer because that's -- we're hearing it from both sides and I don't -- I can't figure it out.

MR. SCHMIDT GRAU: We have the models, and we provide them to anyone that requested. So we are, at least from Vesta's perspective, talking with different ISOs. We are reaching out to them proactively saying, can we provide you updated, accurate models? We see very big interconnect projects in in U.S. coming on board, and it's our bread and butter to sell turbines.

If we have any incident in the grid, it's going to cause a political storm first, so we need to make sure that the equipment we sell is reliable operating, on the grid, and the best tool we have is for the models. So we are really emphasizing utilities to ask and accept the equipment-specific models, and we also are trying proactively to ask what requirements do you have for usability of our models and tools. There's technology out there that can streamline. SGRET B4 is one thing that can be used for EMT/RMS that will significantly improve for utilities.

So we need a mechanism to allow to use the adequate information, and we need ISOs/TSOs to be more upfront with the usability requirements for our models and validation requirements for it. So that's an accountability we have to take on as an OEM, but again, that it's -- we can't afford any reliability issues either, yeah. So for sure, I speak for Vestas here, of course, not for all OEMs. Any concerns, if you heard anything else, please reach out, and we can definitely deep dive into that.

MR. MAJUMDER: Hey, Alex, if I may, just as a GO, who has opportunity to work with all of them who are on the podium. To answer your question, Howard, it's easy. Please go ahead and look at the generation interconnection requirement from each of those ISOs. It's documented. They clearly state we will not accept any user-defined model, so you don't have to get your answer based on speculation. It's there, documented. They don't allow it.

I have had my fair share with working with all of the ISOs where they would want accurate model, and they are absolutely refusing to work with a user-defined model. And then the question we get, so are you saying your generic model is inaccurate? That puts us in a very difficult position because we cannot say that we have given an inaccurate model, which is not true, but it's what it is.

MR. KARPIEL: It's generic, generic by nature.

MR. RODRIGUEZ: This is Fabio Rodriguez. I'm a transmission planner for Duke Energy Florida, and a concern about the models, it's very simple. When we do a system impact study, the OEM sends a model. We do the study. We determine what the impact on the system is, and there we go. Then if there is a new model in our interconnection requirements by FAT 002, there is a requirement that if there is a modified change, the model has to be restarted to see what the new system -- new impacts are on the system, and that's the -- that's the process.

So when you guys come up with a new firmware or a new software upgrade, or, you know, different settings, if there is a modified change, which every utility should have in their interconnection requirements, you know, one of the modified changes, it's a new model. One of the modified changes is, you know, more than five percent in this setting. So if you have that change, the TO, or me as a transmission planner, I cannot accept your model until I do a new study to determine if there is any new impact on the system by those changes, and that's the process that we have. It's a process that should work.

So you know, new models are working for any TO. The thing is that they have to be restarted if there is a modified change determined by the utility, by the TO, and they have for -- you know, due to -- I mean, in FAT 002, every TO, every utility has to expel what the requirements are or what the -- what they call modified change to trigger the restudy.

MR. SHATTUCK: Thank you. I think maybe we'll get back to frequency real quick.

MR. COOK: Yeah.

MR. SHATTUCK: The modeling piece, just keep in mind, we have -- NERC has published modeling guidance that says if you want accuracy in your studies, use a user-defined model simply. They're in -- they're on the website. They're posted. Just Google "NERC dynamic modeling guidance," and you'll get what we recommend as NERC, and you can read that and adopt them if you want to, adopt the recommendation. So frequency question.

MS. CASUSCELLI: Okay. I'm going to interject with a question from the --

MR. SHATTUCK: Yes. Thank you.

MS. CASUSCELLI: -- from online here. So in order to assess all of the Ride-through defined in the standard, do the OEMs agree that a plant-level EMT study is needed to confirm Ride-through?

MR. DAHAL: Absolutely.

MR. KARPIEL: Always a plant -- it's always a plant-level model.

MR. SCHMIDT GRAU: Yes, EMT plant-level models.

MR. DAHAL: Yes.

MR. SHATTUCK: So yesses all around? All right. That was easy. No questions like that before that.

MR. MAJUMDER: Again, Rajat from Invenergy. Before I ask my question, first of all, I would like to thank Alex for a very insightful presentation that he did before lunch. That's precisely what I was referring since from the beginning, and my apology for being the broken record.

So based on Alex's very quantitative presentation, we have seen expanding plus/minus 4 hertz per six seconds has not been established as a sufficient risk. It's clear. We have just heard about all the manufacturers, and especially to Scott's point, that there are probably little less successful manufacturers who are not even around the table. The technology is not there, and they do not see the reason, as of now, because there is no basis of expansion of that.

So my question to the Standard Drafting Team and the leadership is, so far no incident that can be pointed has happened because of that expansion. So if the standard goes ahead with this, we are essentially going to go ahead, make all of those plant noncompliant and open the breaker. How is that helping with our bulk electric system reliability, which has not been the reason of any reliability risk. Again, I'm zeroing in in that frequency Ride-through.

MR. SHATTUCK: Thank you.

MR. AL-HADIDI: Thank you very much. Husam from Manitoba Hydro. So maybe I have few questions based off my involvement in the standard itself. I know I take these standard looking at low frequency 57 hertz for almost five minutes. You guys okay with that, it's not an issue, so you go only 56.1 hertz per six second become an issue or how that really change, because really it's a fluxing issue. It's a time-related issue. So if you can understand five minutes, then what's the difficulties on that for a low frequency? Then I'll go about our frequency, which is normal auxiliaries even for today's surplus machine where, under load rejection, the frequency goes to 70, 80, whatever the case.

So it's not -- it's not abnormal for short time, even for current existing synchronous machine, which deal with the same auxiliary to some level, which is the cooling and all that, which can stand for a large frequency deviation for a soft-load rejection. We just open the breaker. What's the difference? Why you guys think it's an -- a big concern? What I think it's -- if it's a big concern, we need to consider it, but I just want to understand why this concern become significant, where it's not really that much of a change, at least from where we are right now.

MR. SCHMIDT GRAU: I can maybe start. It's the --

all the auxiliary equipment in the turbine is not designed or certified for it, for those values. So as mentioned earlier, also, we manufacturers have to rely on manufacturers, and there's no certification, there's no standard for any equipment we can go out and purchase to put into our machines today that will comply with that. So it will require industrial chains across a ton of equipment. We are not talking inverters here only. We are talking everything. You will have equipment in your substation that is not designed to Ride-through, so you might have your substation tripping offline before the turbines. You might have loads nearby that will go offline as well. So the requirements exceeding, to my knowledge, all industrial practices and other design standards.

MR. AL-HADIDI: Yeah, but it's already existing. As I said today, load rejection on any generator, it create very large overfrequency or very large under frequency, depend, but it's already -- the document is already there which can Ride-through it, so it's not something which is not manufactured before. I see the standard as saying continuous operation or just

integrated operation for certain number, but doesn't
prevent it from running. And voltage per hertz is
already like exception criteria in the standard. So is
it voltage per hertz? Is it what the limitation of the
equipment --
MR. SCHMIDT GRAU: We are talking frequency
plus/minus 4 hertz per six seconds --
MR. AL-HADIDI: Okay.
MR. SCHMIDT GRAU: -- that there is no standard
to, what I at least know, that is designing any
equipment or certifying to that.
MR. AL-HADIDI: Okay. So it does mean it's only
that 57 is okay, and for other frequency up to 62
hertz, that's what you guys guarantee, or is this
really the -- where we are right now, we need to move
to that direction?
MR. SCHMIDT GRAU: Ask if it -- we had to do R&D?
MR. AL-HADIDI: Yeah. Is it R&D?
MR. SCHMIDT GRAU: It's not R&D. It's about we
are not able to source equipment that is designed or
certified to that for the auxiliary systems.
MR. AL-HADIDI: Okay.

MR. SCHMIDT GRAU: Today.

MR. AL-HADIDI: Does that mean that whenever you guys now are manufacturing, the protection setting is set on the border of this curve and you say --

MR. SCHMIDT GRAU: Yes.

MR. AL-HADIDI: So that's --

MR. SCHMIDT GRAU: We have pretty much maximized out, and also to be able to -- there's always margin, but it's -- we have certification for that equipment. I'll let others maybe also reply, but we are maxed out, at least for the Vestas equipment, where we are with our specification today, and we have done the research. Even with long extension here on the equipment, we can't get signoff from any supplier with any of our auxiliary in the frequency.

MR. KARPIEL: So I don't really consider it margin. I consider it a safe operating limit, and then we've already pushed those limits. I'm sure -- I believe we're all saying the same thing, that we're already pushing those operational limits where we feel safe for our equipment.

MR. AL-HADIDI: Okay. What about ROCOF? Is 5 hertz per second something you -- is it something feasible to do, or it's -- where we are in that 5 hertz per second for legacy or for future design?

MR. SCHMIDT GRAU: Vesta's turbines, Type 3 and Type 4, all do 5 hertz per second, yeah. Vesta's Type 3 and 4, it's public. You can go in. They comply with the NOGRR245 of August last year.

MR. DAHAL: For SDRE, that's true only for new units. We do not provide -- we do not have any proof from our legacy turbines that we can go and do 5 hertz per second. That is only applicable for new ones, not the one that has already been installed.

MR. PATTABIRAMAN: Our legacy equipment, there was no requirement for rate of change of frequency at the time these inverters were sold or commissioned. The standard at the time, I think, UL defined maybe 1 hertz per second as a requirement for some of these inverters. And so most of our legacy inverters are tested at 1 hertz per second and safe to operate in 1 hertz per second without tripping. Like I said earlier, changing the software, it's not a simple parameter where you can go and update 1 hertz per 5 hertz per second. Software has to be changed extensively, and our legacy products don't support that. We would have to change hardware to even change software in some of the legacy inverters.

MR. AL-HADIDI: Maybe I'll go to the second -- to the question about transient overvoltage.

MR. SCHMIDT GRAU: So I'll just add a comment on the ROCOF first --

MR. AL-HADIDI: Sure.

MR. SCHMIDT GRAU: -- which I think is important. Avesta's turbine don't have ROCOF protection. It's the equipment, again, that is potentially not able to Ride-through, so I think that's also really important to understand when we evaluate these. I do see ISOs run very detailed, accurate EMT studies for ROCOF. They can do a million hertz per second. The PRC CAP model will never trip because ROCOF is not a protection setting in the turbine. So there is, again, a lot of auxiliary equipment and stuff that is not certified or designed for these things. This is just one example. It's really important to understand that it's just not only inverters. We have a lot of rotating masses, sensors, a lot of things in turbines.

MR. COOK: Folks, we have about two more minutes left, so we'll take one more question.

MR. AL-HADIDI: Yeah. Just quick question about transient overvoltage. They may help us with this question about transient overvoltage. You guys see one second/one-cycle filter, it's difficult to achieve and may create some damaging issue.

MR. PATTABIRAMAN: It's not possible in our inverters.

MR. AL-HADIDI: Well, and understanding that the standard is saying that if you need to protect yourself from damage, you could trip, so it's really -- it still is there to cover for that. But the question now, what's your guys' recommendation how to address it in the standard to ensure that transient overvoltage for just a spike, it's not really a noise or anything in the measurement which cause the unit to trip, how we should deal with it in the standard in better way.

MR. PATTABIRAMAN: There are two ways. I think one is already the NERC recommendation, which is maximize settings to the extent possible, limit instantaneous -- add additional filtering to instantaneous protection internally, and the other path is to kind of adopt 2800.

MR. AL-HADIDI: Okay. Thank you.

MR. COOK: We'll take one more from the gentleman that's behind you.

MR. HAKE: Thank you. Appreciate that. I'll be quick. This is Sam Hake with AS Clean Energy again. So we heard a lot this afternoon about the challenges in evaluating what we cannot do, obviously relating to equipment limitations. One point or a question that I wanted to ask is if you guys see similar limitations also applying to the concept of maximizing inverter performance. We also hear a lot about that, and in our experience, we've run into a lot of issues when we open these questions about how can we maximize performance. We get similar feedback as to what we've heard about what we cannot do and are we limited. So just curious if anybody has comments on that.

MR. KOERBER: Yeah. It's a -- it's a similar concept and some of the -- some of the challenges are similar. Maximize, where's the limit of maximize?

Does it mean you have to invest 10 years of R&D into maximizing it? Generally, maximizations are often understood as make sure the settings are right, make sure all already-available optional features are applied. We actually maximize to the capability stated by the OEM. I think that's fairly straightforward, in my own opinion. And where we run into the same challenges that I was talking about earlier is when we are asking us as OEMs to essentially invent something new that gets more capability out of the already-installed hardware. And parameters can change, software can change, but what happens if a sub-supplier firmware needs to change, or in order to update firmware, you need a better processor? Then it quickly spirals. But I would say structurally similar. It's really do we go beyond stated capability, including all already-designed options? Yeah.

MR. COOK: Yeah. I don't know if you want to add to that.

MR. SCHMIDT GRAU: I want to echo it.

MS. CASUSCELLI: All right. We'll do one last question here if that's okay, Todd. Thanks. There's a question remotely here that asks if any of the panelists work with AEMO and provide source code for their models to the AEMO planners and operators and can speak to that.

MR. SCHMIDT GRAU: I can speak to that. I think AEMO is a very, very good example of the modeling challenges we are facing here in U.S. providing source code. We simplified that source code significantly. That caused a lot of issues with PSSE studies, showing a lot of false positives, which we also see here in U.S. with the generic and standard library models. AEMO is now moving towards full EMT real-time simulation, probably obsoleting RMS, and I think that's going overboard. And to the point earlier, we are a lot of mature manufacturers here. If we go down that route and we start forcing EMT and so strict requirements, in my opinion, it will not kill, but it will slow down innovation, new players, competition in the market significantly. And that's -- I don't think it's healthy for innovation or for the industry as a whole.

MR. KOERBER: Yeah. I assume AEMO -- Australia

Energy Market Operator, or is that another AEMO? I interpret this question as being about Australia, one of the most strict grid codes in the world, requires a lot of transparency, is a significant challenge, but it's also very structured. And our experience working with AEMO is they've also been very open in kind of walking the process with us on what's needed. They've been -- they've had several requirements. I commented on MFRT, multiple fault Ride-through, where Australia has probably the strictest requirements in the world, but they're also very open, very technical in working through some of those challenges with the industry.

Real code, actual source code, actual product-level code is a challenge so far providing this in compiled form where the code -- the source code is not visible, but the performance actually 100 percent matches. The product has been a way to go, implementation challenges. There's many layers when it comes to working with AEMO. I don't think that's a discussion for here, but yeah, we, we work with them extensively, and it's been a journey.

MR. DAHAL: It's not related to that question, but

I do like to bring something to attention as well when we're talking about the model AEMO and all. You know, I think Rajat mentioned, like, most of ISO requires generic model. And what we are seeing from OEM side is people are getting so familiar and comfortable with generic model, that they are changing the model significantly when they're submitting, you know, the model of their plan to ISOs and RTOs. That we know nothing about, right? There is a lack of manpower that I don't think anybody has talked about because not a lot of developers are capable of running the study -- plant-level study on their own, so they have to outsource that study to somebody. And the market is in such a way that there is a, you know, severe lack of, I'd say, knowledgeable people to run the study.

So that model that gets submitted by the OEM to the customer might not be the same model that gets submitted by the customer to the TSO/RTOs as well, so that is also something to keep in mind. Everybody's talking about, oh, OEMs are hiding their control block, we need access to control blocks, we need access to -- we need access to that parameter and that parameter, while forgetting the fact that, you know, if you were to use the OEM/UDM model, you'll get a very accurate representation. And if you have to make changes, then you have to come to us. Then we will tell you what is possible and what is not with generic model.

Then people get very comfortable using those and not realize that changing parameter might drastically change the behavior of the turbine. And, like, recently, a lot of inquiry that comes to us is after the fact that, oh, your model is not -- your IRMS model is not behaving like EMT model, and when you look through it, it's been completely altered, and that's also the challenge that needs to be addressed. And hold the timeline, six-month applicability, one-month applicability, knowing that plant-level study has to be done and is this feasible amount of time to achieve that, that's also -- that also needs to be considered.

MR. SHATTUCK: Thanks, and I think we're out of time, but let's just maybe do one "yes" or "no" at the end. So this last situation was just described, you know, getting a model back that was changed. You have no idea what's in there. We'll go "yes" or "no" from

Thomas down. Have you experienced that?
MR. SCHMIDT GRAU: Yes, pretty much all sites.
MR. KARPIEL: Yes.
MR. KOERBER: Sorry. Could you -- can you just restate the question, please?
MR. SHATTUCK: So the situation that was described where, you know, you've given a model out and then you get it back later from generator owner, utility, or whomever, and it's different, and you had no idea.
MR. KOERBER: I've not personally experienced this, but maybe I'm at a different part of the organization, so I can't comment on that.
MR. SHATTUCK: Okay. Thank you.
MR. KOERBER: I assume yes, but I can't confirm.
MR. SHATTUCK: Finish? You already answered.
MR. PATTABIRAMAN: Yeah, I already --
MR. SHATTUCK: Yeah.
MR. DAHAL: Yeah, absolutely. In fact, we have provided RECA models, and we have received REECC back for some reason.
(Laughter.)
MR. SHATTUCK: All right, good. I think we're

done then.

MR. BENNETT: All right. Well, thank you for our well-informed panelists. I think that was very technical. That was very informative. I think that achieved what we were hoping it would achieve today. So I don't know, just them a round of applause. We appreciate you.

(Applause.)

MR. BENNETT: So with that, I just want to let everybody know there are a number of questions online. We're collating those. We'll get those to the panelists and see if we can get some answers later today. But with that, let's take a 15-minute break, and we'll come back with our last panel of the day to talk about some challenges with the current criteria for PRC-029. Thank you.

(Break.)

MR. BENNETT: Okay. So it looks like we're getting everybody together back in the room here. We've got our panelists seated and ready. It looks like Charlie's smiling at me. So with that, I guess let's introduce our last panel of the day.

So we're going to talk about Addressing the Challenges of Voltage and Frequency Ride-Through Criteria. So to lead us through that is once, again, Charlie Cook from Duke Energy, as well as Howard Gugel from NERC. So take it away.

MR. GUGEL: Excellent. I guess before we start, if we could just have everybody just briefly introduce who they are and who they work for.

Manish Patel, EPRI.

Andy Hoke, National Renewable Energy Lab.

MR. CHWIALKOWSKI: Todd Chwialkowski, EDF Renewables.

MR. LAUBY: Mark Lauby, NERC.

MR. GUGEL: A man who needs no introduction.

MR. COOK: Yeah. Once again, I'm Charlie Cook, and I work for Duke Energy, representing the Standards Committee. Thought of a funny, though. I had this mic on when I walked into the bathroom.

(Laughter.)

MR. COOK: But then I realized, hey, John Belushi did a similar skit on "Saturday Night Live," so I turned it off, so.

MR. GOGGIN: Michael Goggin with Grid Strategies.

MR. GUGEL: I always think of Lesley Nielson and "The Naked Gun" when he did that same thing, too.

MR. COOK: I'd probably do that, too, yeah.

MR. GUGEL: I'm afraid of that. I'm Howard Gugel with NERC, and thank you all for participating on this. I promise I won't ask any questions about models during this -- during this panel. But do want to continue the conversation that we had earlier talking about voltage and frequency Ride-through, and the first question that I'll have is specifically, Mark, from NERC's perspective. And that would be, you know, have we identified -- has NERC identified any challenges about understanding and evaluating the impact of generators failing to meet either PRC-029 or IEEE 2800?

MR. LAUBY: Models, no.

(Laughter.)

MR. LAUBY: One of the -- I think one of the challenges is it reminds me of when I used to work in, in Asia, and they'd come to me and say, well, how much coffee do you want, and I'd say, how much did you make. We're almost in that situation now where we're saying to folks, well, you know, please give me this amount of frequency or voltage, and they say, well, how much do you need, and we can't answer the question, even 2800, of course, which is a global standard, right? It's kind of a -- I'll call it a global foundation, but we haven't done the hard work. And what I mean by "the hard work" is, you know, doing the system analysis to understand what are the frequency response that we need. How do we know that what we're putting in the standard is going to ensure that we have sufficient amount of Ride-through, be it voltage or frequency?

Now, we have some data, you know, some -- and we had -- you know, that's on some of the -- some of the events that Alex went through, which was helpful, though, of course, we did have substantial amount of spinning machines out there to help us with the frequency when there was a need for frequency, or operators that were taking action, like shedding load to make sure the balance is kept.

So I think that's one of the hard parts is having the data and the models and the simulations. We got to get beyond the inverter-based resource and what it can do to getting to what do we need, and then how will -- how will we drive the -- a standard to get there, so what's a good starting point? Well, you know, I'll leave it to the Drafting Team and the people -- and the folks here, but, you know, clearly we're -- it's kind of like a golf site, the old flat start. We're going to start someplace, and then over time, we'll find out as this evolves, if we need more or less.

There are places -- I talked to Jason -- not there yet -- 2800 would actually cause you problems, voltage collapse problems if you -- if everybody finally went 2800. So you got to do this hard work to say, hey, in some places I'm going to have to have less than 2800, and that's okay, it's easy to do that, and some places you're going to need more depending on where you're at, but then that's okay, too. You can do more than the standard, and less, just make sure you have the technical reasons for doing that. So it's not easy, and you need good models and good simulation tools.

MR. GUGEL: Yeah. So to -- so to kind of build on that because now we -- I think we kind of see the issue, maybe we could talk about the magnitude of the problem here. So from the rest of the panelists, from your perspective, you know, what percentage of the existing portfolios would be affected by the draft PRC-029 criteria, and how would that change? Would there be less or more affected if you changed that criteria to meet 2800?

MR. GOGGIN: I can start. So the numbers I've seen, and, you know, we heard on the previous panel from folks on the wind and solar side it's a significant share of the fleet. The numbers I've seen from developers who will be speaking today and tomorrow, 20 to 50 percent of their fleets, and, you know, again, this is out of a base of several hundred gigawatts. And this is -- I should clarify. I'm talking about the frequency Ride-through requirements in PRC-029.

So, you know, 20 to 50 percent of several hundred gigawatts is a hundred-plus gigawatts of existing resources that have major challenges with this, would either require extensive retrofits or complete retirement and replacement of the resources. And, you know, we've heard a lot about the wind, but, you know, anecdotally, we've seen with solar and batteries, I think it's an issue of just, you know, these -- all these plants were designed before the standard was thought of. And so it's very difficult with a few months' notice to go out and find out what the capability of the plant is and, you know, how perform -- just trying to meet this.

And so we really don't know, and, you know, I'll come back to, so what is the solution? This is why we don't do retroactive standards. It's really hard to get them right and make sure that they work for existing resources. There's a long history of doing only prospective standards at FERC and NERC, and it's for a good reason, and on the frequency side, we need that. It has to be on the table. Otherwise, this just doesn't work. And I think going forward, IEEE 2800 is what the industry is designing towards. And, you know, if you make that effective, you know, as of the, you know, basically, when the standard takes effect all interconnection agreements signed after that date have to meet that. I think that works for the industry on a going-forward basis.

Existing plants, again, weren't designed for 2800, and so, you know, we need this -- it needs to be a prospective standard only on the frequency side. And, you know, just given the magnitude of what's at risk here, a hundred gigawatts taken offline potentially permanently or at least for extensive retrofits, is a major reliability risk. We're doing way more harm than any good we're doing if that's -- if that's going to be the result, so this has to be fixed. So an exemption for existing IEEE 2800 for going forward.

MR. CHWIALKOWSKI: I'll go next. EDF, again, EDF renewables, a developer, and I'll go down the path of we've had an opportunity already to do some of our analysis with ERCOT. Now, ERCOT jumped ahead of NERC, and they went forward with their Nodal Operating Guide 245, and they're looking at, at this point, forcing us to maximize -- at least analyze the maximization of our sites within the ERCOT region.

So we've had a chance to work very closely with the OEMs and try to figure out where do we stand with our current fleet. And I have some numbers for you and I don't mind sharing them, but I'll also ask the other developers in the room please share that information. I know some of you have some numbers, and we aren't the biggest developer out there, but our numbers are also pretty significant. So for us, looking at the new PRC-029, similarly, as we looked at NOGRR245 and IEEE 2800, we're looking at almost 40 percent of our fleet being affected by this and affected in multiple ways, not just frequency alone, not just voltage alone. But when you look at our older fleet, our older turbines in the ground, it's both the voltage and the frequency Ride-through that's an issue.

And then looking specifically at ROCOF, looking at the phase-angle jump, looking at multiple excursions, from the OEMs, we're getting the kind of information that says until we test this, I cannot give you a definitive answer. Well, as a developer, I want a definitive answer, right? I want to know how do I respond to the regulator, but I can't get that. And you just heard the previous panel saying that's very tough to come about. How do we test that? The OEMs are my source of truth. If I can't get that information from them, where do I go? What am I supposed to do as a developer or as a generator to get that information to answer the regulator?

MR. HOKE: So, you know, I'm not a generator owner or an OEM. I'm a -- I'm a researcher. So I would basically let everybody just listen to what we've heard from the previous panel, what we've heard from these guys up here. It's a pretty significant percentage of the legacy fleet. I'd also comment, I think this has been brought up before, that when we wrote 2800, IT wasn't designed to be retroactive, and so applying it retroactively causes all the problems we've heard about. Now, and I also understand why people want to apply it retroactively, right? We have a big uncertainty in what does the grid need. We're installing solar and wind plants. They're going to be on the grid for 20 years or more, and we don't know what the grid's going to need in that period. And so there's this desire to be a little bit conservative and get as much Ride-through as we can because we might need it.

But I think what Mark said at the beginning, let's get something that -- what we can get from industry right now without slowing down the deployment of these plants and without causing, you know, PEP companies to go out of business and get what we can now. And in the meantime, researchers like us will try to figure out what the grid is really going to need and have a better idea of that, and maybe we need to revise it and come back to this in the future. So get the low-hanging fruit now, get a good Ride-through standard now that everyone can be on board with, and then if we need to revise it in the future, we can revise it.

MR. PATEL: So I have nothing else left to say really, but I'm looking at some of the notes my wife is sending me right now.

(Laughter.)

MR. PATEL: Just like how my weekends go before I open my mouth in front of family and friends, you know. So I think Andy mentioned this. When we wrote 2800, it was a forward-looking standard, and some of the requirements in there does not exist today in any NERC standards, right? Phase-angle jump never existed in a NERC standard. ROCOF never existed in a NERC standard. PRC-024, for that matter, is not a Ride-through standard. It is voltage and frequency trip-setting standard.

So when we wrote 2800, we had this question: what does grid need and what can IBRs do? And we don't have definitive answer on either of these questions. We tried to find a middle ground somewhere based on engineering judgment, right, a lot of head scratches, and talking to a lot of OEMs about can equipment really do this or not do this. And even then at the time, I remember a very difficult conversation with couple of OEMs on something very specific in the standard, and few OEMs said, Manish, for us to answer this question with any confidence, we have to be able to test our equipment first, and we have never tested our equipment, so we cannot affirmatively say that we can or cannot meet certain requirements, right?

So anyhow, we wrote lot of 2800 requirements thinking about future grid. A lot of folks were involved, 400-plus, and they all agreed to some of those requirements. As far as how many GOs or portfolio will be affected by either PRC-029 or IEEE 2800, you heard OEMs. I think a couple of numbers stuck to my head was one OEM said 40-gigawatt capacity. Another one said 50 to 60,000 units, right? Fifty to 60,000 units. So that's just few examples.

I work -- all my career I've worked on transmission side of the business, so I don't know the numbers. But forward-looking standard, applying it to the equipment that was placed in service five, 10, 15 years ago, and not having that same equipment in a lab anymore to test it for future new requirements is a challenge.

MR. GUGEL: So, and maybe we'll start at the far end and work our way back for this next question. So, and this may be a difficult one to answer, and if you don't have the answer for it, I think that's fine, too. But what would -- what do you think would be the limitations that would need to be fixed, if you will, or changed in order to meet the voltage -- we'll just talk about the voltage criteria -- the voltage criteria that's spelled out in proposed PRC-029? Is there -- what hardware do you think would need to be worked on for that, if you will, or what are some reasonable solutions that we could come to, to maybe not even to necessarily meet that, but to come close to what's shown in PRC-029?

MR. PATEL: Yeah. I'm sorry if I say something wrong. My friends who are OEMs don't come talk to me at the bar. But I think -- I think again, voltage Ride-through requirements were forward-looking requirements. I think at the end of day, it came down to when we were writing 2800 -- and then PRC-029 voltage Ride-through almost mimics the IEEE 2800 voltage Ride-through. At the end of day, it came down to a lot of auxiliary equipment, all this wind turbines and, in some cases, BES and solar inverters and then VSC HVDC, right? The IBR definition includes offshore wind plants that it -- that connect to AC transmission system via VSC HVDC converters.

So all these are very different technologies, and limitations for one technology might not be the same limitation for another technology, but it seems like at the end of day, a lot of these things came down to a lot of auxiliary equipment that is designed on some other industry standards -- IEC NEMA curves, all that kind of stuff that is sourced by OEMs of wind turbine generators, solar PV BES, and VSC HVDC to go along with their equipment. So it comes down to a lot of auxiliary equipments.

MR. HOKE: Not a whole lot more to say there because, I mean, it's sort of summarized pretty well what we've heard from the OEMs in the previous panel. You know, it's equipment specific. Sometimes it might be auxiliary. Sometimes might be that you need some power for the controls at low voltage for a certain amount of time, but -- and sometimes maybe it's a software change. But as we heard, even with those software changes, you have to go back and retest that, so it's not just a matter of updating new firmware. I'm basically just summarizing what we've already heard, so I'll leave it there.

MR. GUGEL: Well, maybe I can take us in a little bit different direction then because there's a question that I've had. If we made a switch, it seems like the vast majority of inverters that are at least on the legacy equipment and may be specified for now, tend to be more grid following. If you made a switch to take those inverters to grid forming, would that maybe solve some of the issues that we're talking about for voltage and frequency Ride-through?

MR. HOKE: All right. I'll jump in if no one else wants that one.

(Laughter.)

MR. HOKE: I think you're going to run into a lot of the same issues, and maybe even more issues because now you're not just doing Ride-through, you're also doing a whole different type of low-level control for the inverter. I know that some of the inverters that are out there can be retrofitted to become grid forming. Others need a new inverter to become grid forming. Again, it's a commit-specific question. And the Ride-through issues, that doesn't make the Ride-through issues go away. The Ride-through issues are still there. You still need the auxiliaries to work. You still need the control power to be there. So I don't think it necessarily solves that issue. It's another super important issue to talk about, but I don't know if it necessarily helps with the Ride-through.

MR. GUGEL: Good. That's a question that folks have asked me in the past. And, you know, I didn't stay at a Holiday Inn Express recently, so I didn't have a good answer for it, but I thought maybe some of the smarter heads here might have a good one for that.

MR. PATEL: I think that question may have some value in terms of what does grid need. Does grid following gives what grid needs versus what grid forming, but I don't think you can compare grid following Ride-through versus grid forming Ride-through, and challenges, and all that kind of stuff. I think that question may have value when we talk about grid needs.

MR. GUGEL: Yeah. Just the question that had come up for me was, does the fact that maybe it's less dependent upon the frequency that's provided by the system allow for some different controls that might make the ability to Ride-through different as opposed to looking at the frequency on the system and reacting to that internally into the inverter.

MR. PATEL: So I think repeating myself and repeating with everyone else on the previous panel, I think a lot of this limitations is not only the wind turbine or the -- or the inverter. It's a lot of auxiliary equipment, right? Grid forming won't change in the auxiliary equipment. It remains same, so.

MR. GUGEL: Right. Okay.

(Cross talking.)

MR. HOKE: -- for the synchronization issue just real quick there, and maybe grid forming helps with that, but that's just one piece of the puzzle of the Ride-through, right, everything else that everyone else had mentioned.

MR. CHWIALKOWSKI: Before we go down that path of grid forming/grid following, let's go back to that previous question of, you know, will hardware fix a lot of these voltage Ride-through issues? And I'll go back to the source of truth, but I also want to -- I also want to expand a little bit upon that because as a generator owner operator, we're being asked that right now, what will be necessary to maximize our turbines down in the ERCOT 4 region, for instance? And I want to explain that process to you a little bit better because this is not a trivial process.

We rely on the source of truth, the OEM, to give us that information about the turbine. But that's just the first step because then you take it to the substation, and you start looking at how are we protecting the components of the substation? If I make any change downstream at the turbine level, how is that going to affect my substation? And then once I have a better idea of how that affects the plant on the medium-voltage side and the high-voltage side, then I go back to the -- I hate to say it -- the modeling side, which could take far more time to even go through that process because, again, we look at the source of truth, the OEM for the models. And that could take six months to a year sometimes to get those models from that and then expand the models to the entire plant.

Now, if you have a homogeneous system and you have one OEM, one model type, that works out pretty well. You put two model types out there, it gets a little more difficult. Two OEMs each having one model makes it even more difficult. We have a site with three OEMs and multiple model types. It's easily a year to get a model set together to submit. That's the process that we go through, but again, to answer your question, on the hardware side alone for the turbine, the OEM. I mean, if we can't get an answer from them in a reasonable time, that's where we stand.

MR. LAUBY: I don't want to hear myself. I think the challenge here, too, is to understand what's the risk. I think some folks kind of mentioned this before. We saw some charts that Alex put up on the current situation based on certain events. If we just ask folks to provide us what they can, and I don't know how you define that, what's reasonable versus unreasonable, and then looking forward, making sure that we stay to one particular standard that we can count on. And realizing that, again, sometimes when you do the technical studies, that you may actually not want to implement a Ride-through criteria that might be like a 2800 or 029. Maybe we need something a little bit shorter. I think -- I think we can stay in front of the risk. I think the main -- the main thing is to ensure that those can -- those devices out there that can provide more within the reasonableness that -- you guys can decide what's reasonable versus unreasonable -- to take advantage of it.

There may be some regions, though, or interconnections where that's a real issue for them, and Texas might be one of them. It's a small interconnection, very -- more and more dependent on the inverter-based devices there because they're building a lot of them over a period of time. And so they may have a bit more of a need in certain interconnections versus other interconnections.

MR. GOGGIN: I totally agree with that. I think, you know, the need needs to drive this, not the capabilities, and that was a little confusing this morning kind of hearing the -- from the Drafting Team that they kind of -- you know, that their logic was, oh, well, IBRs can do this, so we're going to make them. And that's backwards, it's discriminatory, and it's just not a good standards practice.

You should define the need, and I think it's clear that the plus or minus 4 hertz per six seconds is not based on any real need, based on, you know, the charts we've seen this morning and the 10 NERC reports. You know, there's never been a frequency deviation that large, and, you know, just thinking about what would happen. If the frequency is down at 56 hertz, every conventional generator would've tripped off, you know, or at 59 hertz, all the load would've tripped off around then, too. You know, what's the point? What are we trying to achieve here by making IBRs stick around while every -- the entire other power system -- rest of the power system goes black?

I don't think -- I don't -- I haven't heard any -- I've been asking all day. I think -- I don't think anybody has heard a good technical justification for what we're trying to do here. You know, these -- the bounds here are just so far beyond, you know, everything that I think is based in, you know, actual needs, and so what is that need? And yes, it may vary by interconnection, you know, the standard connection. NERC has done analysis showing it's -- you know, even with very high penetrations of inverters, maybe with, you know, extremely high contingencies, you know, 3X, you know, losing 7,000 megawatts in contingency, you still have very tightly-controlled frequency.

And with IBRs that have fast frequency response, grid-forming capability, and other things, frequencies are even more tightly controlled with lots of batteries, with, you know, controlled renewables. I think we're moving to a where frequency is even more tightly controlled than it is today. And so let's, you know, first establish that need and then work backwards from that, and then set the requirements based on that. Let's not go with this backwards route of, oh, we can, you know -- we think inverters can do this, so we're going to make them.

MR. GUGEL: The only caveat that I would provide -- and sorry, Mark, I'll speak out of turn, and you can clean up for me. The only caveat that I would provide is the examples that were provided this morning and that kind of show some of the events that occurred, were just specifically rated to -- related to inverter-based resource events that we've seen over the last three or four years. It doesn't say that we haven't seen frequency excursions larger than that. It's just that we haven't recently seen those.

If you go back in history, we have had in Florida somewhat, fairly large, you know, frequency excursions that have occurred. And we're trying to protect not just for some of the things that we've seen recently, but for events that could occur on the system that are much more drastic than that. We're trying to stay out of that.

MR. GOGGIN: Sure, and I was including Uri in that, which was not an IBR. It was a gas event.

MR. GUGEL: Well, yeah, but, again, that's just some of the more recent. If you were to go back to some of our more historic legacy issues that maybe got us into why we got our name and our purpose you would see a little bit more of those issues that are there. And, Mark, I think Edison probably had some good comments --

MR. LAUBY: Yeah, Edison, and I saw that. No, I think you're right, Howard. I think that -- I don't see this as a discriminatory act. I know the Drafting Team is struggling with what -- with the tools they have and the experiences they have. I think the challenge has been that we're saying throw a ball, but we won't tell them how fast we're throwing it and how far it's got to go because we haven't done the studies. Back in the day when you were adding a generating plant, you ran all sorts of different contingencies, and you made sure that you didn't impact your neighbor, that you had all the models right, and you knew how that thing was going to play within the system. It seems that we haven't done that in some -- in these cases, maybe because there's just so -- the number is so large and has overwhelmed the system.

But we have to get back to, to your point, what do we need and how do we tune the system, and that includes the in grid-forming inverters. How are we going to tune the system so the controls work together and provide the self-healing smart, you know, resilient, reliable grid that we envision this is going to result in? Thank you.

MR. PATEL: So may I add something real quick? I think -- I think we have been focusing -- so we're in a football season, so let me give you an analogy. My team lost the football game over the weekend. I'm glad I'm here so I can forget about all that. But they were -- they're a pretty good defensive team, but they couldn't move the ball on offense. You can't win the game, right? So we are talking about Ride-through capability, this frequency deviation for this time. And there is -- a big other side of it is that, what does IBRs do, or any other resources do, when the frequency is abnormal for certain amount of time?

The new IBRs probably can respond much faster during frequency deviation, right? Battery energy storage can respond much faster. I think -- I think we can put some solutions together for the system where the frequency's arrested before it goes too low or too high, right? I don't think we have to only focus on plus or minus 4 hertz per six seconds, or whatever other hertz per 299 second, the other piece, which is not part of PRC-029 right now, which is okay. But I think there are other ways to make sure that the system together holds, right, and the frequency arrested, and it turn around back to 60 hertz in a -- in a timely manner.

MR. GUGEL: Yep. Charlie, I've kind of dominated the questions here. Have you -- have you got anything you'd like to add at this point?

MR. COOK: No, keep going.

MR. GUGEL: Okay. You know, one of the -- and I'm going to go off script here. It's not even a question that we've got here, but one of the things that we saw in the past was an issue with sampling frequency, and the fact that -- sampling frequency. So the issue that may be harmonics or subharmonics may be affecting what the inverter or other equipment sees as being a frequency or voltage excursion, how do we solve that problem? Is it -- is it -- I mean, it'd be very easy to in my mind to say, okay, well, I'll just get some sort of a frequency smoothing device or sampling issues or whatever. But is there -- is there some way that we can maybe address that and come away with a feeling that we're actually sampling what's occurring on the system and not getting influenced by harmonics that might be out there?

MR. HOKE: That's not in the script, but we can say a little bit about it. So right now, Manish and I and a whole bunch of other people in this room are writing IEEE 2800.2, which is the procedures to verify conformance IEEE 2800. And from a really high level, what that does is it takes an IBR unit, which is an individual turbine or an inverter, and do some tests, whether that's in a lab or in a field or even in a HIL setup. And just doesn't try to make sure that it can do any certain thing, but just make sure that its behavior matches its model. And then you take that model or that IBR unit, which is now verified to match the behavior of the -- of the device itself, and you build a plant-level model, and you do a couple -- a few simulations, fairly simple simulations, really, on that, to make sure that it meets the behavior and -- that you need for my IEEE 2800, for example, or from whatever other source requirements document you're looking at.

And so you can use a process like that to verify whether a plant is going to trip, for example, when there's a phase jump and confuse that phase jump with the frequency change and trip. If you can then play a phase jump through that plant model, and if it's going to confuse -- if it's going to get its PLL confused and think, oh, whoops, the frequency's 72 hertz, I'm going to trip, it's going to fail that test. So you can use a process like that.

You would also see it in the testing phase 2 because you would've put a similar event through the event -- through the actual hardware inverter or turbine, and you would've seen, oh well, that turbine didn't behave how we hoped it would. And so I think through that sort of a process, which, you know, like I said, right now we're writing this in 2800.2, but these are processes that manufacturers are already using. Manufacturers are already testing their devices, not exactly using the procedure we're writing because we're writing them now, but they're also validating their models against their hardware, at least I believe all the manufacturers that we saw up here this morning are. And so that's one approach to that question is sort of a testing -- combination of testing and modeling, I guess, would be the short answer.

MR. GUGEL: Okay.

MR. LAUBY: One thought I had on this is, what we're getting to is, you know, inverters themselves have wonderful characteristics of being able to move very quickly. And so we need to be able then to ramp up our sampling or monitoring very quickly because they need sometimes to act at the speed of light to protect themselves. So I think, you know, the -- I think that the sampling rates have to increase or monitoring rates need to increase so that then the remedial actions and mitigations can take place, and also, that that information can flow to other inverters in the area. I'm going off, this is the reason why, and, of course, then they can act accordingly, too.

MR. CHWIALKOWSKI: I'm going to add to Mark's comments because I think this is a great place to digress, as an example, PRC-028, for instance, asking for additional data. I don't know of a single developer generator that would say we want less reliability. That's not the case. That is absolutely not the case. And looking at PRC-028, looking at ERCOT's NOGRR255, looking at IEEE 2800 Table 19, we know this is not easy. This is hard. This is not easy stuff. It will cost money, but it's -- you know, even though it's hard, we're willing to do that because we think data is the answer to move forward, to move prospectively through some of these requirements because having the right data will help us make better decisions in the future.

Yes, it's hard, yes, we're willing to do it, yes, we have a understanding, but it's not wholly understood yet what kind of equipment we'll have to retrofit out in the field to get this data, but we're willing to do it. That's where we come from, and that backs up your comments, too, Mark.

MR. COOK: So there's question from the script that I'd like to have addressed right now, and it's Question Number 3. And it says, what are reasonable solutions to ensure legacy equipment can be compliant with the frequency criteria in Draft PRC-029 Attachment 2?

MR. GOGGIN: Yeah, I can offer some thoughts there, and I think it's instructive to go back to Order 901 from FERC. They pointed to the language that's in PRC-024 that has equipment limitation exemption process, and, you know, there are some things similar in the current draft of PRC-029 for the voltage-related requirements. I think that's what is needed for these existing resources.

You know, I think we heard on the last panel that there needs to be reasonable accommodation for, you know, using declarations or attestations or something like that in cases where it's just not practical to test because, you know, the OEM that built a piece of equipment is no longer there, or, you know, it's no longer supported by the manufacturer, or just, you know, you just -- in many cases you can't physically test for these things. You have to run simulations and kind of guess what it was, and that's -- you know, I think that's -- again, it's why we don't do retroactive standards. In many cases, proving a negative retroactively is extremely challenging. And so there needs to be some reasonable accommodation, yeah. We don't want to have a blanket exemption, but at the same time, like, you know, there has to be understanding of the realities of how you can validate this.

And, you know, I think, again, having this equipment limitation in there is essential. You know, there's a massive cost potentially incurred here if we don't have an exemption for the existing resources. And with, you know, no real upside reliability, it's just going to be, you know, a hundred-plus gigawatts taken offline.

And, you know, I think, you know, we've heard about, you know, what Order 901 says. I think having exemption for frequency is entirely consistent with FERC's directive there. If you read it contextually -- I have a little insight here. I'm not -- obviously, I don't work at FERC and I'm not a lawyer, but FERC was responding to comments that I helped ACP CIA write when it talked about the exemption for voltage Ride-through. And we'd had a back-and-forth in the NOPR, the notice of proposed rulemaking, with FERC about the voltage requirements, and basically we said, you know, there might be some challenges with existing resources, and then FERC was basically saying, okay, you can have an exemption for existing resources that would have to replace hardware to meet the voltage requirement.

FERC was silent on frequency Ride-through requirements because we weren't talking about that in the comments that we were submitting. FERC was clear that they were okay with exemptions for resources that would have to replace their equipment, and, you know, FERC's logic is there's not a lot of these, they're going to be replacing their equipment anyway as inverters age out, and, you know, we're repowering the wind fleet anyway, and so there's no reliability risk here, so we can have these exemptions.

That logic all applies for frequency Ride-through, and so I think, you know, there's very clear logic from FERC as to why there should be an exemption process that looks like what's in PRC-024. And FERC actually, again, pointed to PRC-024 when they were directing NERC how to set up this exemption process.

MR. GUGEL: Yeah. I would even extend on what you said earlier, not only looking at reliability benefit, but reliability deficit for the retirement of, you know, hundreds of gigawatts of energy that's out there. You know, that should be taken into account, too, so I think -- I think that's a really good point.

MR. LAUBY: I would add to that, I think it's important that we understand -- we planning engineers understand what is the state of the network. What is the state of the generators in the sense that when I do my studies and I have an overfrequency, I know which ones are going to go out and which ones are going to hang on. I also want to understand the implications of the ones that go out on the ones that did stay on, and do they create more of a frequency issue. So I think going through the process of -- you know, going through the attestations and understanding the state of the generators that are on the network, plus, of course, those that we're adding, that when we do our system studies, we'll have a much clearer picture of really where we stand.

MR. GUGEL: Yeah. I think, not to get too far off topic here, and we want to go to the questions online and in the room. I think one of the things that today has pointed to is the fact that we need to have these same conversations about models as we get into the next phases of 901. And I think it's going to be very crucial that we get us in the room again and talk about those issues through that. With that, let's see if we have any questions here in the room or online. Bueller?

(Laughter.)

MR. YEUNG: Yeah, I'm on. I had to get clearance from Jamie first before I asked this question because I'm a -- I'm a moderator for tomorrow. But today my question is solely from the ISO/RTO perspective. My name is Charles Young with Southwest Power Pool, and I'm not sure if there's many other RTOs in the room here today, so I thought -- I want to raise this issue.

First of all, I want to point out what Mark said. I'll call that Letter A. Mark mentioned this expanded frequency response provides a lot of automation and adds resiliency to the grid. So that's very important knowing that the proliferation of IBRs is jeopardizing some of that stability, you know, operating in the unknown states, right? The second thing is what Manish said, and I'll call that Letter B. Manish mentioned very clearly PRC-024, it's not a Ride-through standard. It's a -- basically a frequency limitations-settings standard to prevent, you know, resources from dropping offline during conditions or the where the grid is, you know, in excessive frequency declines or rises. So as an operator, as an ISO/RTO operator, I'd like to get to Letter A, Mark's model, the future resiliency and automation, produce light things to work and not have to intervene to avoid Letter B, you know, this relay operation when frequencies are either excessive or high.

So how does an ISO do that? How do -- how do we get resiliency without getting into PRC-024 operations? The only tools we have as operators is operator intervention, and that can be a range of things, right? We can reconfigure the grid, we can put resources on resources online, and, as an RTO, it could be out of merit, more than likely out of merit, or we can do curtailments of those assets we believe are at risk. So that's our choice. I'm not hearing a lot today about the operator's tools and how these benefit the operator.

MR. LAUBY: I left it on this time just in case. I think the way to get to it, of course, as a -- I'm thinking operational planning drop, right? You got to -- like you say, we got to model this stuff. We got to know -- we don't want to be running the system in unstudied states, so we need the information on what the expectations are. How are they going to behave? Every one of these plants, how are they going to be behave under certain system conditions so that when we study them ahead of time, you can pre-position yourself rather than kind of go, oh, surprise, guess what, another thing happened and another thing happened.

The idea that we need a unique models for every one of these, I hope we can get around that, but at some point or another, at least being able to understand that during certain events, what your expectations are going to be. And that feeds right into your IRO standards about contingencies that you're going to run on your system because you have a certain expectation that when a line-to-ground fault comes on, you're going to lose 500 megawatts of solar voltaic, and so then you got to make sure you're ready for that, as opposed to running blind.

Of course you can haul the planners in later on if you want and say, hey, you got to fix this. That's in the planning stage, right? And that's when you start getting into, well, what the standard is and what's -- what equipment we're going to be acquiring going forward. But I think you're -- right now, you're right. You're kind of running a little bit blind because you don't have the models, and you don't have the knowledge of how those devices are going to perform during certain events. You're kind of learning on the fly.

MR. PATEL: So real quick, Charles, I think that's a million-dollar question that we don't know the answer to. I mean, you asked the question from ISO/RTO perspective, but if you think -- I used to be a transmission owner or protection control engineer until recently, and, you know, to protect my system, I need to know what the system will look like or what the system will be able to provide in terms of falcon or what type of falcon, and then I can set a protection. But I think it's a million-dollar question that we don't know the answer to yet. Thinking of 24/7, 365 days a year and then 20 years out in future, right, you have very different operating scenarios when you go through different days, different months, different years, so.

MR. CHWIALKOWSKI: I'll add one thing to that, also, just to answer your question. I think to help you out, we do need better modeling, no question, but better data also is important. I mean, that's two of the things that I think are very important that we can look at retrospectively versus prospectively, where we have the technical capability and it's also commercially reasonable. That's where you establish that balance, right, of going down that path. And I'm going to quote Alex from earlier this morning where he mentioned, you know, what is it that we should focus on moving forward? I think a couple of solutions are right there, right in front of us -- better data collection and then better modeling -- and for that, we need our source of truth, the OEMs. So, Alex, you're there.

MR. SCHMIDT GRAU: So Thomas, Vestas, here. Just kind of a segue of this as well. Grid forming, grid following, at least from Vesta's perspective, is the same hardware. That's different software at current states. So I think it's also important to understand when we talk about the PRC-029, for me, that's a capability requirement. It's not about how the plant has to perform. It's an envelope on it, and with these tools of we're going to get data, better modeling, and so on, what is the kind of vision to start developing some more direct performance requirements on how to do

-- because what are we going to do as an OEM? What should we design our control for if the frequency goes to 58 hertz for hundred milliseconds or 200 milliseconds or 300 milliseconds?

I don't -- I don't see that kind of in the performance on the standards today, and that also creates a lot of different implementation possibilities and different behavior on it. So I'm looking for some direction on performance requirements and how that should look like.

MR. GUGEL: I'll take the first step on that. Nice for the compliance guy to jump in here, I know, and you're all fading. You know, I really would look to the technical experts to develop some reliability guidelines around that. You can kind of think of what we -- what we set up at NERC for reliability standards as being the guardrails, if you will, the extremes. But I think once you operate within that, then really you're looking toward your technical experts to decide what should be a best practice. And I'm going to use air quotes there because everybody's hates to do that because they're public utility commissions, hold to them the different things. But, you know, when you're within that, there's probably better ways to operate and less better ways to operate. I don't think, at least from our perspective, we wouldn't define that in a reliability standard, but instead, that would be more operating practices. Any other thoughts from the -- from the panel here on that?

MR. PATEL: So real quick, I think -- I think -- I think what you mentioned is very important, but I think the answer to some of those questions will be system dependent, right? A 200-megawatt solar on a 500 KV system can perform a little bit differently than a 50-megawatt on a 46 KV system, right? So I think it's very difficult to standardize how to utilize some of those performance requirements. I think it'll go based on system studies and need of the grid, and all that kind of stuff. So maybe your reliability guideline, that kind of provides an educational material to engineers about how to utilize some of those capabilities, but I think standardization is too early for something like that.

MR. SCHMIDT GRAU: It makes perfect sense because

I think it's very important to, you know, as you said, Manish, also, we should have the equipment, try to correct the frequency before we hit the envelopes, and that, for me, goes in into some of the performance. I know we have extremely fast sampling from a plant level. I can talk more on that in one-on-ones, and that sometimes turns out to be very negative as well. In Texas where you have a very small deadband of frequency, we sometimes go in and out of frequency control 25 times in four seconds, you know. So we're re reacting too fast because there's a performance requirement stating you're not allowed to have any artificial delay on your response, so we just like bang in and out, in and out constantly.

So that's where some of these performance and understanding is also faster is not always better. We also have to slow down things, and that's where we need to balance it.

MR. GUGEL: You probably also have situations where you have units fighting each other, right --

MR. SCHMIDT GRAU: Yeah.

MR. GUGEL: As they're popping in and out, they're actually reacting to each other on that too, which --

MR. SCHMIDT GRAU: Ask Todd about that with his three OEMs in one plant.

MR. COOK: Yeah, excuse me. Scott, you stood up while ago, and I didn't recognize you. I apologize. Do you have a question or did it get answered or asked?

MR. KARPIEL: (Off mic comment.)

MR. COOK: Okay.

MR. GUGEL: I tried to lead us there, but, you know.

(Laughter.)

MR. VENKITANARAYANAN: Nath Venkiti, GE Vernova. My question is, I think there is a general intent to try and align PRC-029 somewhat to IEEE 2800, you know, not exactly. But like, the Ride-throughs curves seem to have a basis in IEEE 2800, but there are also some substantial differences, and I wanted to understand if those substantial differences are intentional or if they might actually be accidental. I'll give you some examples.

Like for example, IEEE 2800 has an MFRT requirement, and it starts off with a paragraph, and the first bullet under that paragraph says that the IBR shall not be required to withstand more than four consecutive voltage dips. Okay. That first bullet was picked up in PRC-029. Now, IEEE 2800 then goes on to say in the second and third and fourth bullets that if the voltage dip is less than 50 percent, then it only needs to withstand two consecutive voltage dips and not four. So those subsequent bullets were eliminated from PRC-029, and that kind of raises a question in my mind as to whether this is really intentional or accidental.

Another example, IEEE 2800, the example that I brought up this morning about the one-cycle Ride-through requirement for transient overvoltages. Now, I heard that there is -- there's kind of -- some kind of intention behind that, but accidentally, what that has done is impose a requirement that the IBR units withstand any transient overvoltage that is less than one cycle, an infinite magnitude of that voltage that is less than one cycle, right? That's exactly what it's been translated to.

Other examples: IEEE 2800 said wind turbines, which a typical wind turbine with its blade at its

12:00 position can be -- an offshore wind turbine can be as tall as the Empire State Building. So IEEE 2800 said, if you have mechanical resonances during MFRT events, then the wind turbine is allowed to trip to protect itself from those resonances. That part is not in PRC-029. Another example IEEE 2800 says V over F, for -- right? For V over F, it said -- it referenced certain equipment standards for auxiliaries and said if you go outside the envelope of V over F or F over V capabilities as specified in those standards for those auxiliary equipment, then you're allowed to modulate reactive power so as to adjust voltage and try to stay within those limits so that you don't trip. That requirement was f eliminated from PRC-029.

So again, I'm just asking for the view of this panel is, do you think this is intentional or maybe accidental?

MR. GUGEL: So at the risk of providing a non-answer, I'm not sure that this panel could speak to that because they weren't on the Drafting Team. They weren't the ones that made the decision on that. I think that would be a good question to have the

Drafting Team and then also the Standards Committee as they're looking at making this modification. But I don't know that this panel could speak to the intent as to whether or not it was intentional or not.

MR. VENKITANARAYANAN: Okay. Yeah, I didn't find another forum to ask the question, so I just wanted to see if there was any -- if this --

MR. PATEL: May I -- may I? So with all due respect to Husam and Shawn, I'm not a member of the Standard Drafting Team, but I joke that I'm an honorary member because I'm equally vocal as an observer --

(Laughter.)

MR. PATEL: -- and they value the input that encourages me to talk. I think -- so consecutive voltage dip and transient overvoltage are the biggest nightmares of my life. I'll remember it until I'm dead. The Clause 7 in 2800 -- that is voltage and frequency Ride-through -- is a good 20-page material that was written by a lot of folks very carefully, and PRC-029 is, what, three page requirements document? So we went into 2800 and picked up few tables and few statements and put it into PRC-029.

I think that's the risk, right? This 20-page story in 2800 became a three- or four-page writeup in PRC-029 with all the measures and every other fluff that needs to go into the NERC standard, right, and that's actually the problem. I do agree with you, Nath. I think we have to be very careful that when we go and pick some bits and pieces from 2800 and put it somewhere else, we have to make sure that the dots are connected appropriately so there is no ambiguity or unintentional consequences.

MR. VENKITANARAYANAN: Thank you.

MR. MAJUMDER: I'll just offer this to answer Nath's question that it was not accidental. I'll leave it there. Whether it -- whether or not it was intentional, I would not get into that. But what I would offer is the standard of thinking needs to understand models are very important, but let's not make reliability standard only thinking of PSCAD and PSSE. It way beyond PSCAD and a PSSE. It's a physical equipment, everything Nath just said. Those insights are extremely important, so I'm so glad that in Technical Conference, we have great participation from the OEMs who are sharing their insight.

This is one, in my mind, is a missing piece. The Standard Drafting Team needed to consider that what are the physical insight. Going into a PSCAD model and changing from 1.7 to 1.8 can be done in seconds, but the consequence of changing that 1.7 to 1.8 does not happen instantaneously. There is a massive process that is there, and even in the model, not just mention about the mechanical resonance, not a single PSCAD model would capture this. We have issue of temperature rise on a DC chopper, which model is capturing that?

So therefore, when we get a question like, okay, let's find out what hardware element, I think the previous panel said many times it's not -- you cannot just put your finger one specific hardware element, that's the reason. It can be a very complex combination, so it's not only just an IP. Of course IP is an issue, but the outcome of so many complex element creating a trip, it is -- it is not easy. So let's think beyond modeling space, let's think from an equipment perspective, and listen to all these expert while we are making further decision. Thank you.

MR. BENNETT: Okay. Thank you. I don't think we're terminating this panel just quite yet. I think we can take a couple questions from online and give them an opportunity to participate?

MS. CASUSCELLI: Yeah. Yeah. Thanks, Todd.

MR. BENNETT: Okay.

MS. CASUSCELLI: I'll ask a couple of questions from online. So most of the discussion so far has been for land-based resources. Are there different voltage-related concerns for offshore wind?

MR. GOGGIN: I'm not going to get into the technical details. I would note part of the reason why I have mentioned the need to have the standard apply prospectively from the signing of the interconnection agreement and not being placed in service as it is in the current draft is because of the long lead time for offshore wind, but also, you know, other land-based wind, you know, and solar and batteries also can have long lead times between, you know, when they sign the interconnection agreement and -- I'm sorry -- when they, you know, start developing the project and, you know, buy equipment and develop settings and things like. And so, you know, having the requirements take effect for plants in service as is in the current draft would not work for these longer lead assets. And so that's -- you know, that's necessary to, you know, set the requirements and have them take effect based on resources -- signing the interconnection agreement after the date, you know, the implementation of the standard.

MR. LAUBY: I was talking to my friend from EDF here because they have a lot of offshore and, you know, many times the collector systems are DC, and one would have to do the study work to see if that has any implication. But certainly they're more rugged offshore than they are onshore, but that might be one study that needs to be done, see if there's implications of the AC-to-DC collection and the -- another set of inverters there.

MR. GUGEL: Probably interconnection methods would be another way of looking at it, whether or not it's radial or whether or not it's connected at multiple points, because a radial one would have different voltage issues, I would think, than something that would be more of a network connection.

MS. CASUSCELLI: All right. Thank you. One more from online. The OEM panels do not seem to represent all of the vendors, and so how does NERC plan to address the different IBR technologies that were not represented on the panels?

MR. GUGEL: I guess a good answer wouldn't be we're just going to make up some stuff for the rest of it.

(Laughter.)

MR. GUGEL: No. So there's -- this is still a very public process, and I know the Drafting Team in the past has tried to reach out to OEMs to get as much information as they can. I'm hoping that we have even more OEM representation online at this point. I know that the Drafting Team and others would welcome any comments and any input that you would have from your perspective on that, too. Certainly from active OEMs, we know there's also some that, you know, are no longer in production. It'd be very difficult to get information from those, but kind of information that can be provided to help further a knowledge about what is out there on the system and what is going to be projected out there in the future would be very much welcomed.

MR. GOGGIN: I would just chime in that this is all the more reason to not do retroactive standards. It's extremely challenging to make sure that those standards work for everything that's out there, including the stuff that was built decades ago by somebody that no longer exist, and prospectively to use 2800 because it's what the industry is designing towards, and so that process has already played out. You know, Order 901, we're having to do this very quickly and that approach of not retroactive and IEEE 2800 prospectively is the safest way to avoid causing major unintended problems.

MR. GUGEL: Yeah. So I understand the concern, but we have many standards that are retroactive standards when they go into place. So I understand that we need to -- we need to have a concept and a -- and a -- and a -- and a -- and a context of how this all fits in, but just because something is a legacy piece of equipment doesn't mean it needs to have reliability issues and reliability constraints placed around it as it operates on the system because it can affect reliability just as importantly as things that are placed in the future.

MR. GOGGIN: Yeah, I don't disagree with that. I think, you know, again, if we do have concerns about existing resources, we should start with the, you know, reliability needs and work backwards from that and design a solution. You know, this is an extremely fast process, and we need to be careful we're not causing unintended problems in this process. We can -- if there are real reliability concerns that are left on the table I think there's an opportunity to come back and address those later. But I think there's much greater upside -- or downside risk of, you know, taking off -- unintentionally taking off large amounts of operating resources and causing a reliability problem than there is in, you know, maybe missing a reliability problem that might emerge at some point in the future, then we can fix that later.

MR. PATEL: May I -- may I say a few things? I think I agree in general that legacy equipment cannot be detrimental to the reliability of the system, right, but I think we also need to look at a little bit bigger picture. I wanted to mention this when Alex was presenting earlier today, is that all the disturbance reports that have come out in last seven, eight years, those were because of something like momentary cessation or incorrect measurement of frequency, things like that, a spontaneous reaction of controls to system disturbance.

When we are talking about frequency Ride-through, I think we are talking about plus or minus 4 hertz per six second. So I think if we fix some of those issues that were actually brought up, right, in disturbance reports then -- and then we make sure that the new IBRs do provide frequency response in a manner that we don't actually get to the boundaries, right, I think -- I think we'll have our problem solved.

MR. GUGEL: I think potentially that's the case, yes. The only caveat that I would provide to that is, we continue in every one of these disturbances to see more things that come up, and I think being reactive for each one of these is not really a long-term solution for reliability. I think, instead, if you set the parameters and then -- I hate to use the word "force," but have generator owner, operators, OEMs, others go out and validate that they can perform within those parameters, then you don't get into the situation where you fix one problem, and then a year later, you have another issue that occurs on the system that is somewhat related, but not exactly the same as what that previous one was. I think that's the concern that, at least we've seen from NERC, is that yeah, we go out and fix things as they happen, but you can't just continue to be reactive. We need to at least draw a line in the sand and say, these are the performance parameters that need to be met.

MR. LAUBY: Yeah, I agree with you Howard, and again, this gets back to handwaving. We got to get beyond handwaving and actually do the hard work, do the modeling, do the simulations. I don't know if what you say is true or not until I see the runs, so we can't do it heuristically. We got to understand what the risks are that are mounting on the grid and how do we mitigate them, and what's the pathway to the end state.

So I agree with you a hundred percent, Howard.

MR. HOKE: One other quick comment on that, though -- so I see the -- I see both sides of this. Like, I see wanting to go back and fix some of the older stuff, at least the stuff that can be fixed, without going to extreme measures, but I also see the side of, we want to get a Ride-through standard through in a reasonable time frame because in the meantime we're installing even more legacy stuff day by day. And so maybe there's a path where we separate those two things, just put that idea out there, where the legacy -- the legacy retroactive stuff maybe is separate from the -- from the forward-looking stuff.

MR. GUGEL: It might be a good conversation for some of our panels tomorrow, I think that'll be good, yeah.

MR. BENNETT: That's kind of what I was thinking, also, on this is maybe this is a good spot to break for today. I will let everybody know that we have collected many questions online. And today, I think we're going to run out of time to do the Slido polling and kind of go through that exercise, but tomorrow there'll be an opportunity for that, and I think we're going to circle back to some of our online themes tomorrow once we have -- can maybe discuss that a little bit more internally. So I think with that, how about we give everybody a round of applause for this great panel.

(Applause.)

MR. BENNETT: So yes, not just this great panel, but everybody today. This was very informative, this was a great session, and I do think we have maybe just a couple small things here at the end. Sue Kelly's with us today. She is our -- first of all, she's a NERC Board member, and she is the liaison to the NERC Standards Committee. And do you have any remarks to share here at the end of the day?

MS. KELLY: I do.

MR. BENNETT: Would you like to come over here and share them or share from over there?

MS. KELLY: (Off mic comment.)

(Laughter.)

MS. KELLY: I just want to thank everybody who came today, both virtually and in person, and I want to thank the Standards Committee members who are doing all of this work on top of their day jobs. Very much appreciate that. And I want to thank the Drafting Team because I know they've spent countless hours working on these issues, and I appreciate those who came today to explain the decisions they made and why they made them. We owe them our thanks.

I want to talk a little bit about what I've heard today. This is a scary thing for me to be doing it, but I'm going to do it anyway. First, I think the more information that we have, the better, and the earlier that we have it, the better. I think that's one of the things. A lot of stuff is coming out today that if we had had earlier would've been better.

David Ortiz noted that FERC issued Order 901 based on the record before it. They did what's known as notice and comment rulemaking. They gave notice, they took comments, and then they made a decision based upon the comments that they'd gotten. And in retrospect, there might be some people who wish they'd been more active earlier on in that docket at FERC, and there's a lesson there. That lesson is be there or be square.

You really need to participate both at FERC, and now we're obviously following onto the work that FERC assigned us, so it's important to be active earlier rather than later.

Second, what I heard is that the role of the original equipment manufacturers is crucially important. They need to be part of the dialogue. I'm glad they came today and spoke about their concerns, and I hope they stay engaged. We heard a lot about the inability to comply with certain of the proposed requirements of PRC-029. I hope they, in turn, leave today with a better understanding of our need at NERC to ensure that their equipment does not contribute to reliability events in the future. And more and more of it is going to be installed, so that issue becomes more and more important.

Third, I loved Alex Shattuck's Venn diagram. I love Venn diagrams from sixth grade. It's one of the few mathematical concepts I was able to absorb. How much future Ride-through performance should we demand from our resource base, and how much are we going to have to pay to get that? We cannot use today's regional grids and generation mixes to decide how much is enough because, again, as David pointed out this morning, we're anticipating a very quick ramp-up in IBR-based resources. And so the ground is shifting under our feet, and the requirements are going to have to shift as well.

The conservative reliability-based response is to do what I would call the Ride-through standard equivalent of belt and suspenders to, you know, make sure eight ways to Sunday that we are covered on reliability, but that could come at a very high cost, so we have to balance those things as we go through this. We also need to consider the issue of legacy generation, as was just referred to, and the efficiency and effectiveness calculus that Alex laid out for us may be different for these resources than for new ones.

So I'm going to be thinking about all this tonight, and I'm sure you will as well. Hopefully we'll have another productive day tomorrow. We'll be back 9:00 tomorrow, and I will note that breakfast and lunch are up one level -- this is my most important duty -- up one level in River Birch A, and there will be signage to direct you. Breakfast will be available at 8:00. I hope to see everybody there. Thank you very much for your time and attention and deep thinking today.

(Applause.)

MR. BENNETT: So with that, Sue shared my logistical information, so I believe we're adjourned for the day. So thank you very much, Sue.

[Whereupon, at 3:49 p.m., the Technical Conference was adjourned, to reconvene at 9:00 a.m., Thursday, September 5, 2024.]

CERTIFICATE OF TRANSCRIBER

I, Charlene Williamson, do hereby certify that, to the best of my knowledge and belief, the attached transcript is a true and accurate transcription of the indicated audio recording.

I further certify that I am neither attorney nor counsel for nor related nor employed by any of the parties to the action; further, that I am not a relative or employee of any attorney or counsel employed by the parties hereto or financially interested in this action.

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