



# Transcript of **Technical Conference Day 1**

Wednesday, September 4, 2024

*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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Panel Discussion with Q&A: Addressing the  
Challenges of Voltage and Frequency Ride-Through  
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Moderators: Howard Gugel (NERC) and Charlie  
Cook (Duke Energy)

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(NREL), and Michael Goggin (Grid Strategies  
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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.

21

22

Please note that there will also be a Slido during today's conference. It's NERC's policy and practice to

1 obey the antitrust laws and to avoid all conduct that  
2 unreasonably restrains competition. This policy  
3 requires the avoidance of any conduct that violates or  
4 that might appear to violate the antitrust laws. Any  
5 NERC participant that is uncertain about the legal  
6 ramification of a particular course of conduct, or who  
7 has doubts or concerns about whether or not the NERC's  
8 antitrust compliance policy is implicated in any  
9 situation should consult NERC's general counsel, Sonya  
10 Rocha.

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

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

14 PARTICIPANTS: Good morning.

15 MR. MANNING: Welcome, and thank you for being  
16 here. Many are here in the room. Many more, I think,  
17 are here on the call. I struggle this morning to  
18 describe this meeting. I was having a conversation  
19 with someone and I would say, it's going to be fun, and  
20 then I'd stop and say, well, perhaps it's not going to  
21 be fun. It's going to be exciting. Well, perhaps it's  
22 not going to be exciting. I think where I ended up

1 with, it's going to be hard. I think that's fair.  
2 What we're doing is going to be hard. Perhaps it's  
3 evolutionary, I think, certainly evolutionary what  
4 we're doing today and tomorrow. Revolutionary? Maybe.  
5 Could be revolutionary.

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

19 I feel like today we meet head on one of our very  
20 first transformative decisions. I recently read the  
21 book, "The Last Days of Night," written by Graham  
22 Moore, and it's a story of Westinghouse versus Edison,

1 a story of invention versus industrialization perhaps.  
2 It's a story of AC versus D.C. It's a great read. I  
3 highly recommend it if you're part of our industry.  
4 It's fascinating. Not everyone would find it fun or  
5 exciting. Some might find it hard, but I think if  
6 you've got any history in our business, you would  
7 really enjoy reading about the early days of the AC  
8 versus DC.

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

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

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

19 So there you have it. The risk is sufficient.  
20 The technology is sufficient. The time is sufficient.  
21 What remains is to just get it done. Hard or easy  
22 becomes irrelevant. All that remains relevant really

1 is to chart a pathway forward, the pathway that sees us  
2 confidently step into the future of reliability. So  
3 that's why I'm here today. I suspect that's why most  
4 of you are here today, and I thank you for being here.  
5 I thank you for the skills that you bring to the table.  
6 I thank you for your engagement, for your knowledge. I  
7 thank you for your presence here in the room or on the  
8 phone. I thank you for your willingness to seek a  
9 solution where those who've gone before us have failed  
10 to find a solution. We're going to need all of your  
11 skills in the next 30 hours or so. Certainly what  
12 we're doing is evolutionary, revolutionary perhaps.  
13 The next few hours will write this story for us, so I  
14 thank you for being here, I thank you for your time,  
15 and I thank you for getting it done. Mark.

16 MR. LAUBY: Ditto. David?

17 (Laughter.)

18 MR. LAUBY: So anyway, good morning, everybody,  
19 and that's a wonderful setup for the -- today's  
20 meeting. I did want to kind of think about how we got  
21 here. And so I talked to my old friend, Faraday, who,  
22 in 1980 -- in 1830s, excuse me -- came up with kind of

1 the first machine with a -- with a magnet and a  
2 spinning disc, and, you know, we've been making  
3 improvements to that from the beginning, DC machines,  
4 AC machines. I always want to start thinking about  
5 that group, AC/DC, but let's not go there, and the  
6 whole system, of course, being synchronized was a big,  
7 big chore. And we -- it was really all about managing  
8 mechanical energy, you know, taking mechanical energy  
9 and moving it, transporting it to where we need to use  
10 it, of course, then transforming that to actual work.

11 And when we think about NERC and all the  
12 activities that we all work on, it's all about avoiding  
13 what we call the evil three, which is the instability,  
14 islanding, and controlled -- uncontrolled cascading.

15 In fact, Steinmetz has been quoted saying that we  
16 created the largest machine that people have ever built  
17 in the -- in the world with the interconnected systems.

18 But, you know, it's kind of like when I'm listening to  
19 my 1970s and 1980s tunes on the radio and my daughters  
20 say, that's before the turn of the century, dad,  
21 because that's not where we are today.

22 You know, we have a significantly new way of



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

21 And we now have high-speed inverters that can  
22 really do whatever we want them to do, and we're trying

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

19 And I really -- to, you know, Rob's point here,  
20 thank you for all the work that you've done to date,  
21 how much work you're going to have to do to get us to  
22 that next step, an important, I think, inflection point

1 in our industry. So as I mentioned before, Steinmetz  
2 was talking about the largest machine that was ever  
3 built. We're building the largest computer now, and it  
4 will be one that will be fast moving and can provide  
5 services that perhaps we never even dreamed of and be a  
6 more reliable, more resilient, more secure, and we need  
7 everybody's help to get there. So thank you. With  
8 that, next, I'll ask David to provide opening remarks.

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

15 (Laughter.)

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

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

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

20 And then I want to note that, you know, I'm here  
21 and several other FERC staff members are here, and our  
22 role today is fundamentally as observers. We're going

1 to have a really big bite at the apple in November  
2 after you complete your work here and NERC submits the  
3 standards to us. But the instigating action that kind  
4 of brought us here was Order Number 901, which the  
5 Commission issued in October 2023, and that directed  
6 NERC to develop reliability standards for inverter-  
7 based resources in four areas: IBR performance, data  
8 and information, model validation, and then planning  
9 and operational studies.

10 We gave NERC a really tight timeline for this,  
11 and, you know, we're not necessarily sorry about that,  
12 but it definitely is really pushing the limits of the  
13 processes that NERC has, and we appreciate NERC and all  
14 of you working toward those. You know, specifically,  
15 we ask that you -- that in NERC, finish the standards  
16 and submit those at the Commission for approval on a  
17 rolling time -- on a rolling basis in three years.

18 And, you know, as you know, even a standard for which  
19 there is essentially no disagreement, just some details  
20 to work out, typically takes about a year to develop.

21 And so to actually solve complex technical problems and  
22 submit to us a standard is a -- is a pretty high bar,

1 and we understand that. And so, you know, to Rob's  
2 point, yes, this is a difficult task that we gave you,  
3 and to a certain extent, it's just beginning. You  
4 know, perhaps this will be a great conference and this  
5 will be a model for the next sets of standards, who  
6 knows, but, you know, there's still a lot of work to be  
7 done, and I want to thank Jamie for managing the whole  
8 endeavor. I'm surprised that she still has hair.

9 And I want to kind of address one thing with  
10 respect to Order Number 901. I know that within the  
11 discussions that you've been having specifically about  
12 this standard, but also about the standards which  
13 passed recently, there's been a lot of discussion about  
14 the order and language in the order. As a Commission  
15 staff member, and especially as an engineer and not as  
16 an attorney, I'm not in a position here to interpret  
17 the order, but one thing that I can say is that the way  
18 the Commission works is that it -- the Commission makes  
19 its decisions based upon a record. And that record  
20 that we -- that the Commission had in last October was  
21 what it -- is what it used in order to make the  
22 decisions in Order Number 901. If there is new

1 information that's brought to bear that would cause the  
2 Commission to reconsider that, then that's something  
3 that the Commission has done in the past, and I presume  
4 it would be open to do -- to do in this case.

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

18       The record, though, that we had indicates that  
19 this is something that needs to be done. As Rob said,  
20 this is something that NERC has been investigating  
21 since 2016 after the Blue Cut Fire disturbance and the  
22 -- and not only is this a -- an eight-year-old problem,

1 at least, right? It's one that is -- there's a wave  
2 that's coming that's tremendously important for us to  
3 get a handle on. And that's the fact that, you know,  
4 EIA projects now, and it perhaps -- and this was last  
5 year -- perhaps it's changed already -- that fully half  
6 of U.S. electricity will be -- electricity will be  
7 produced by inverter-based resources by the end of the  
8 decade, right? So, you know, not only has it been a  
9 long time, but there isn't any time to waste.

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

16 (Applause.)

17 MR. BENNETT: Okay. Good morning, everybody.  
18 Okay. So thank you for all the opening remarks from  
19 our -- from our three speakers that kind of help set  
20 the tone for the meeting today. So now my name's Todd  
21 Bennett. I'm chair of the NERC Standards Committee.  
22 I'm kind of here to walk through the objectives of the



1 agenda, but, Mark, just so you know, it looks like  
2 we're going to do this through some high-voltage rock  
3 and roll today, so there's your AC/DC reference.

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

15 So let's kick this off, and, you know, our agenda,  
16 kind of just to review the agenda, I saw kind of three  
17 main objectives that came through the agenda upon my  
18 initial review. So the first one is very specifically  
19 on communication. So one of the objectives of this  
20 agenda was to communicate the technical issues and to  
21 level set on those throughout industry, OEMs and any of  
22 the other roles that we all play in industry. So we

1 all come here, you know, and we're all going to learn  
2 something today probably just a little bit.

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

19 So one thing you should be prepared for is there  
20 is a finite amount of time for each one of these panel  
21 discussions, so there's between 45 minutes or an hour  
22 or so. And there is a preset amount of questions, so

1 there's about 10 minutes allotted for each question to  
2 make it through. Panelists may find that there's an  
3 opportunity to kind of build on some of the panelist  
4 responses before each subsequent panelist. That may be  
5 the case. If not, I don't want to, you know, frame  
6 your responses at all, but you may be able to make the  
7 most of our time and kind of build on some of the  
8 responses from before. So just be cognizant of there  
9 is kind of a time constraint on some of the panel  
10 discussions.

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

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

6 And with that, I don't think I have anything else  
7 to share. That's my agenda review. And I believe  
8 Jamie is ready to review the summary of the FERC Order  
9 901 and Milestone 2, so we'll let her get set up here,  
10 and I believe she's going to go through a presentation  
11 with us.

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

21 So next slide, please.

22 Quick summary for everyone. The order came out in

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

20 Next slide, please.

21 So as indicated, there are really four main issues  
22 of this data sharing assuring that the data is

1 available. We're talking about high-speed sequence  
2 event recorders, fault recorder data, stuff that has  
3 not been traditionally needed at conventional  
4 generation. So those needed to be installed, and we  
5 needed to ensure that the requirements were in place  
6 that required the sharing of that data to those who  
7 needed it, either for modeling or for doing those  
8 studies, or just for situational awareness, being able  
9 to monitor the onsite impacts and making sure that that  
10 was visible.

11 There's model validation, ensuring that not just  
12 once it gets thrown into the model, hasn't been  
13 validated. We're looking at also verifying during the  
14 interconnection process has the model accurately  
15 represented what was as built, if there was design  
16 changes that happened during the initial  
17 interconnection studies and we're moving into the post  
18 commercial operation, and it's not operating the way it  
19 was designed to as the way the model practices and  
20 simulation, then there's an issue there. So we want to  
21 make sure that we're building an effective model  
22 validation throughout, planning and operational studies

1 that leverage that. And performance requirements were  
2 listed last, but, of course, we get to those first.

3 So next slide, please.

4 Another thing about Order 901 was that it  
5 references three different types of IBRs. So just to  
6 make sure that we're level setting on what those IBRs  
7 are, registered IBRs for the purposes of FERC Order  
8 901, that is any IBR that is going to be registered as  
9 either, what we're referring to as Category 1 or  
10 Category 2. Now, the distinction between registered  
11 and unregistered IBR has to do with the earlier FERC  
12 Order 2022 that required the expansion of requiring new  
13 IBR generator owners to become registered and into the  
14 NERC regulatory environment. We're looking at  
15 aggregated IBR of 20 MVA and up connected at 60 kV. So  
16 this is an expansion of the IBR and generator owners.  
17 A lot more people coming on board.

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

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

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

19 How we get that aggregation is going to be a  
20 continual conversation, but it's actually not part of  
21 the performance requirements in Milestone 2. The only  
22 ones that are identified within Milestone 2 are those



1 registered IBRs that are going to be part of the  
2 Category 1/Category 2 generator owners. Those would be  
3 interconnected at 60 kV and up with the aggregation of  
4 20 MVA and up.

5 Next slide, please.

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

20 So this presentation and this whole conference,  
21 while we're looking at -- specifically at Ride-through  
22 and the very specific aspects, I know we want to get

1 into exemptions and criteria discussions, but we don't  
2 want to lose sight of the fact that there's still a lot  
3 more that we need to be able to do and within the next  
4 two years. So the scope of work for November 4th, we  
5 look to be on track. We only have one standard that  
6 hasn't passed, and I think we'll be able to get to a  
7 solution at the end of this conference.

8 Next slide.

9 Okay. So just to break up the three standards.  
10 First Project 2021-04 at a new standard. Again, we  
11 decided to break out the IBR versus the conventional  
12 generation. So where we had PRC-02 that was focused  
13 on, you know, capturing this information, we've created  
14 a new standard. This Drafting Team decided to put  
15 forward PRC-028, looking at disturbance monitoring and  
16 reporting requirements for IBR. This is installing new  
17 sequence event recorders, fault-recorded data, and  
18 making sure all of that information is being provided  
19 through those requirements. So there might be a  
20 trigger, such as a request from a planner or operator,  
21 for that information. There's a small period of time  
22 that that data is just be -- required to be held on an

1 ongoing basis, but we're talking about potentially  
2 terabytes of data after just a couple weeks. So  
3 there's not a large period of time that that data is  
4 required to be preserved unless a trigger is put  
5 forward by the planner and operator to initiate that.

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

22 So PRC-028 looks at making sure that the

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

17 Next slide.

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

20 So Project 2020-02, PRC-024, we're looking at  
21 frequency and voltage Ride-through requirements. It's  
22 why we're all here today. We're looking at

1 establishing capability-based Ride-through criteria and  
2 performance-based Ride-through criteria. So the  
3 difference there being the design piece where you have  
4 -- whether or not you've communicated what the unit is  
5 capable of doing versus how it's actually performing in  
6 practice. During a voltage or frequency excursion,  
7 what is it actually doing? Does it match? And so we  
8 need both of those things in order to be able to align  
9 them and make sure that they're the same. There's  
10 going to be differences based off of things that are  
11 as-built versus as-designed, but we've got to be able  
12 to make sure that we're moving forward with  
13 comprehensive solutions. That means we need both of  
14 these, and that's what PRC-029 does for IBR.

15 PRC-024 was modified slightly. It takes Type  
16 1/Type 2 wind. It takes synchronous condensers and  
17 synchronous generation. So we're retaining PRC-024  
18 with those changes to ensure that those assets are  
19 covered. So PRC-029 really focuses on those  
20 asynchronous, you know, Type 3/Type 4 wind and PV where  
21 we're looking at IBR that need to be looked at a little  
22 bit differently.

1           Next slide, please.

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

22          So PRC-030 is really what ties PRC-028 and 29

1 together. Again, that's that three-legged stool that  
2 are all really needed in order to be that single  
3 solution.

4 Next slide.

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

16 The data-sharing aspect comes from PRC-028, so  
17 that left-most block. It's really going to be the  
18 thing that's going to be relied on to perform those  
19 analytics, but we got two other boxes down there that  
20 are critical, which is Milestone 3 and Milestone 4 are  
21 going to require this information. So having that  
22 data-sharing capability, the ability to trigger sharing

1 that data is essential for validating models, making  
2 sure, again, as performance is being incorporated more  
3 into these standards, that we have performance  
4 evaluations during model validations and not maybe just  
5 five-year stage testing based off of what -- or the  
6 unit can do and based on the facts and circumstances at  
7 the time that unit is tested.

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

20 So next slide.

21 At this point, we'll open it up for any questions.  
22 I don't know if there's going to be questions. If we



1 can move to the Slido slide as well. Well, while  
2 that's getting ready just to go through how we're going  
3 to be doing the Q&A, within the room, we've got two  
4 microphones set up, which are between the two hallway  
5 the two columns here. If folks have a question to  
6 ask in the room during any of the presentations or  
7 panels, please line up behind the microphones. We'll  
8 alternate between questions in the room and online. So  
9 the online Slido is going to be available during  
10 presentations. We're going to have the -- those  
11 questions locked so there won't be any questions that  
12 will be able to be asked at any other time. We're  
13 going to close that down and reopen it every time we  
14 have a -- the possibility to go to a Q&A.

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

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

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

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

14 (Laughter.)

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

16 MR. MAJUMDER: Thank you so much, everyone.

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

20 MR. MAJUMDER: Absolutely. My name is Rajat  
21 Majumder. I work for in Invenergy, which is a  
22 renewable energy developer here in the U.S., and I'm

1 also on the Standard Drafting Team of PRC-029. So  
2 great presentation, good setup of the meeting.

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

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

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

1 MS. CALDERON: Okay.

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

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

21 MS. CASUSCELLI: All right, a couple more. David  
22 McNeill from Certrec is wondering, "Does NERC

1 anticipate the replacement of synchronous generation  
2 with IBR-based generation to lessen the severity of  
3 frequency events?" We'll probably get through that.

4 MS. CALDERON: Less than the?

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

7 MS. CALDERON: Not sure I understand that  
8 question.

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

13 MR. SHATTUCK: Yeah. I mean, I'd say probably  
14 not. I mean, the thing we can certainly say is that as  
15 we transition towards more IBR and higher penetration,  
16 things are going to change. If we do nothing, right,  
17 and it's all grid following inverters, and, you know,  
18 all the synchronous machines are gone, then things are  
19 going to happen that we don't expect. They will  
20 probably be worse than what we've seen. Now, if we do  
21 this in a thoughtful way and replace those synchronous  
22 machines with machines that are, you know, tuned right,

1 with the right parameters or the right capabilities  
2 like we're going to talk about today, then we could be  
3 relatively certain, you know, if we go forward, that  
4 even if the events change their nature, that we're  
5 capturing that with our, you know, study work, right?  
6 If we do better studies and study what's actually going  
7 to happen and study what will come next, then whatever  
8 happens as far as the changes that happen, we'll be  
9 able to mitigate those as much as we can.

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

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

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

20 MS. CALDERON: Okay. The preconference comments  
21 that were provided as part of the larger set of  
22 comments that we requested from industry, we do not

1 intend to publicly post those. We are collecting those  
2 as a matter of our, again, record of development. If  
3 we as part of our filing have additional follow-up  
4 questions, we might reach out to those individual  
5 comment submitters for additional information. If it's  
6 additional information that's requested by FERC during  
7 our filing, we're going to provide that as well, but we  
8 have no intention to post the full comments.

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

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

16 MS. CASUSCELLI: Okay.

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

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

1 later.

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

6 (Break.)

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

14 (Technical difficulties.)

15 UNIDENTIFIED SPEAKER: Lithium batteries.

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



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

6 Yeah, maybe next slide, please.

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

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

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

1 grandfather that project to move forward to include --  
2 associated with this standard.

3 Yeah. Next slide, please. Yeah.

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

16 From the analysis, actually, the -- one of the  
17 issues is identified that the existing PRC-023 -- PRC-  
18 024-3, is just equipment protection setting standard.  
19 It's not sufficient to cover the IBR units. In that  
20 SAR, it's proposed to address those reliability risks  
21 to propose a more suitable performance-based  
22 reliability standard.

1 Next slide, please.

2 Yeah. The Standard Drafting Team start from  
3 actually combined those two SARs and start working on  
4 this standard -- the standard to work on this project.  
5 Actually, the project start from 2022, I think -- yeah,  
6 2023. At that time, actually, after the extensive  
7 discussion, I think as mentioned by David and Rob,  
8 actually, the Standard Drafting Team realized that  
9 there's difference between the synchronous generator or  
10 the traditional generator and the IBR units. So  
11 approach-wise, actually the Standard Drafting Team  
12 decided to revise or modify the PRC-024-3 to retain the  
13 reliability standard as the protection-based standard,  
14 only applicable to the single generator and the  
15 synchronic condenser Type 1 and Type 1 wind turbines,  
16 and to create a new reliability-based standard, the  
17 PRC-024 -- PRC-029, address the inverter-based  
18 resources to Ride-through these system -- voltage and  
19 the frequency excursions.

20 Actually, at the time of the last year, actually,  
21 the FERC Order 901 came out. Actually, the Standard  
22 Drafting Team decided to coincide with the Ride-through

1 standard proposed by the attribute standard -- no,  
2 sorry -- the need to understand and follow the FERC  
3 Order 901.

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

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

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

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

13 So next slide, please. Yeah.

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

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

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

18 Next slide, please.

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

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

13 So we included the designing -- the design and  
14 operate, and it was -- that wasn't integrated in Draft  
15 Number 2, moved away from Draft Number 1, which was  
16 only about just operate the IBR, and R1, it just focus  
17 on the Ride-through the voltage. And we had two table  
18 for this Ride-through, and the two -- the table is one  
19 for the wind IBR and other -- and then -- and the  
20 second one for other IBR technology. And the reason  
21 for that, we want to have as wide as possible voltage  
22 Ride-through criteria with understanding that the

1 system short-circuit level and they (inaudible)  
2 significantly change. And even the load itself -- IBR  
3 load will integrate it a lot on the system, and that  
4 the need of Ride-through -- of a larger voltage Ride-  
5 through, it'll be expected for ability to mitigate any  
6 future risk. For that reason, we were -- we went to  
7 the two tables and with understanding some limitation  
8 could still exist for the wind technology.

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

20 And also Bullet Number 3, it used to be as a  
21 separate requirement in the standard in the first  
22 draft, which is the -- which is the positive sequence



1 instantaneous voltage jump. But we said it was -- we  
2 thought it may -- it make it more fit to have it as an  
3 exemption because really only if unit trip, then if  
4 your voltage was -- if your base angle jump more than  
5 25 degrees, then you could use it as exemption from the  
6 compliance part, and you don't have to worry about it  
7 as part of -- if you don't -- if you don't have a  
8 protection, if you don't have this trip there, so you  
9 don't have to be worried about the compliance and how  
10 to present it as a requirement.

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

19 Next slide, please.

20 This is the measurement. Actually, the  
21 measurement were changed somehow to reflect the -- some  
22 feedback we got from multiple stakeholder, and I

1 believe to the stage where now it add more clarity. If  
2 you have any question, we can answer it at the end of  
3 the -- at the end of presentation. But for now, next  
4 slide, please.

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

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

22 However, but we understood that could be

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

12 Next slide, please.

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

1 mitigate it or deal with it.

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

5 Next slide, please.

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

16 So for that reason, we said, instead of allowing  
17 them to trip, we said, no, don't trip because really,  
18 it may, it may not be able to provide any support after  
19 the fault recovery. So we say you could block if your  
20 booster sequence voltage below .1, but at the same  
21 time, if you booster sequence goes above .1 within five  
22 cycle, you have to reconnect to the system, and you

1 have to start -- continue exchanging current, and you  
2 have to meet the requirement as stated in the 2.1 or  
3 2.22.

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

17 Next slide, please.

18 For the 2.5, this is for the recovery from the  
19 event itself. And for the recovery, as I said, the  
20 flexibility is added there. We said it needs to  
21 recover, and that was part of the FERC order, within  
22 one second. At the same time, it has to recover fully

1 for the pre-disturbance megawatt, and -- but we  
2 understood that it may not be able to go to the full  
3 megawatt because of some water or some change in the --  
4 in the -- in the -- in the capability of the IBR is not  
5 for tripping an individual IBR unit. It's only -- if  
6 it can -- even if we trip some IBR unit, but it can  
7 maintain its power after the disturbance, we say this  
8 should be a compliance. It shouldn't be -- have an  
9 issue with that, but we understand in some cases you  
10 may not be able to cover for 100 percent, and we give them  
11 a flexibility, which is going to be provided by their  
12 associated transmission planner or operator or  
13 coordinator.

14 Next slide, please.

15 This is the fun part, which is R3, which is the  
16 frequency Ride-through. We had to struggle with this  
17 one, I must say. We understood the system is going to  
18 change in the -- right now, the system is going through  
19 significant change, and the IBR technology is going to  
20 be -- penetration will be increased significantly in  
21 the system. And people have not enough experience or  
22 exposed to the system to the high-frequency event or

1 low-frequency event. So we try to write something  
2 which, in our mind, how it's going -- the system going  
3 to behave within the coming four, five, six, 10 years,  
4 and what's the availability needs for the system.

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

18 And the challenge was for the ROCOF, which is 5  
19 hertz per second, but we understood it's -- this value  
20 cannot -- it's very difficult to calculate during the  
21 fault. So we make it very clear that this is not  
22 during the fault event. It should be after the fault

1 and should be for really actual load and generation and  
2 balance event.

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

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

20 Next slide, please.

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



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

17 Next slide, please.

18 Here, we also provided the mechanism and to whom  
19 this exemption needs to be submitted. At the same  
20 time, we said that how you need to deal with it in the  
21 future, if you are -- if your exemption has been -- you  
22 replace some of the equipment and if there is any

1 request, additional information from transmission  
2 planner or transmission operators or RC for additional  
3 information. It could be modeling, it could be other  
4 information which may help them to assist the risk and  
5 to model or to try to include this as part of their  
6 study to understand their limitation within the  
7 equipment.

8 Next slide, please.

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

12 Next slide.

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

19 Next slide. Thank you.

20 MR. WANG: Yeah. One more thing I want to mention  
21 is, like, for the -- at the first draft, right? We  
22 also include the transformer voltage, the requirement,

1 along with the attribute and 800 standard. But during  
2 the Drafting Team, the development and also the  
3 participate of the attribute Standard Team, right? We  
4 realized that it's very complex issue at this point,  
5 and we just remove the -- remove that requirement and  
6 just put the one atom in the attachment of the Table 1,  
7 yeah, such that actually, we just try to avoid the  
8 instantaneous overvoltage tripping, yeah. That's not  
9 allowed, yeah. Just one point we just mention, yeah.  
10 Thank you.

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

20 The second one, which going back to my comment  
21 earlier this morning, the sufficiency assessment of the  
22 risk should be data driven. And if we look at some of

1 the earlier even that has happened, I fully agree that  
2 there has been, even on where large amount of IBR  
3 tripped off. Majority of them, if we review the NERC  
4 alert carefully were due to wrong settings. So if we  
5 try to solve a problem of some equipment settings being  
6 wrong with a very broad stroke of making the  
7 requirement much more stringent, I do not know if  
8 that's the right way of doing things.

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

20 So all I'm trying to say that asking for a  
21 frequency right requirement thinking it may happen in  
22 the future appear, to me, be pure speculation. So I

1 would like the entire room to consider those fact and,  
2 again, humbly request to establish the risk sufficiency  
3 assessment based on data that's available to us. Thank  
4 you.

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

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

20 MR. GOGGIN: Thanks. Michael Goggin with Grid  
21 Strategies. A question about the frequency Ride-  
22 through curves in PRC-029. Can you talk a little bit

1 more about the source of those curves and the technical  
2 justification for the relatively wide frequency bands  
3 in there?

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

13 And we under -- also the base on this limitation  
14 we have right now in BRC 24, it was based on the actual  
15 physical limitation on thermal turbine, which is not  
16 the case in many cases for -- other than IBR, the Type  
17 3, where it have some -- it's still in the integrated  
18 system. The other one is already buffered by the  
19 inverter itself. So we -- the thought was the  
20 opportunity is there. The need of the system will --  
21 the inertia will go lower. Even the short sector will  
22 be going lower, and that's mean the rate itself can

1 widely spread as a voltage dip where it can impact  
2 significant number of load and the load IBR base load.  
3 And this all can create a significant movement of the  
4 frequency.

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

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

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

8 (Laughter.)

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

22 The second thing is the way the standard is



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

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

21 MR. AL-HADIDI: Thank you for the questions.

22 Manish, we discussed some of this one before. So maybe

1 in the first part, which is about the system strength,  
2 where it was -- where it was designed, the idea were --  
3 the team were, the Drafting Team, that we did not touch  
4 the stability part of the IBR. So we said we are -- in  
5 the standard itself, we did not speak about the, what  
6 you call the rising time or starting time, or is going  
7 -- is it going to be stable or not stable. So we  
8 understood this can impact the stability, and there's  
9 the third phase, which is the Milestone Number 3, which  
10 is, you know, about the operation, and that need to be  
11 caught at that stage of the analysis, and I believe  
12 that will be -- could be advised to revise some of  
13 these parameters or re-look at it as part of that --  
14 part of investigation.

15 But if it -- if that part provide now  
16 recommendation for change of that to maintain for  
17 whatever short-circuit level system become because you  
18 cannot say that I design today, system have changed,  
19 now for reliability, I don't have to do anything about  
20 a system change. System event happened, everyone  
21 cannot Ride-through, and the system can collapse or  
22 reliability issue. So I think that need to be

1 addressed as part of the how the phase three or my  
2 phase three of the standard need to look at it, and in  
3 that case, we looked at it where it need to be looked  
4 at, the stability of the IBR.

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

7 MR. PATEL: Mis-operation of protection.

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

9 MR. PATEL: Just real-life things.

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

20 In the PRC-030, it was very clear stated that if  
21 it was for mis-operation, you don't need to investigate  
22 it, and is no -- no corrective action is needed. So it

1 was already exempt by the IBR tripping for -- mis-  
2 operation protection was already included, in our  
3 opinion, at least in the PRC-030, which maybe this a  
4 good point for discussion, if that was really the right  
5 way to do it or not, but that's where we are.

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

8 MR. AL-HADIDI: Yeah.

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

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

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

10 MR. AL-HADIDI: Yeah.

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

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

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

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

10 Second of all, you mentioned that, well if the  
11 design can do it, why not? It's not about just the  
12 IBR. We'll have transformer which are not under PRC-  
13 029, and I don't want to speak for them because we have  
14 enough expertise today within the room. I'm looking  
15 forward to the manufacturing panel this afternoon. We  
16 have representative from FOSDA, Siemen Gamesa, Hitachi  
17 Energy. They are the top at their field. Please hear  
18 from them. If you are going to have transformer  
19 operating in such a low frequency ban, there are going  
20 to be many other issues, unintended consequence. It's  
21 going to make the transformer for no apparent reason.  
22 That's not the right thing to do, but transformer is

1 not covered within our PRC-029.

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

12 MR. MAJUMDER: Yeah.

13 MR. PATTABIRAMAN: Hi. Dinish Pattabiraman from  
14 TMEIC, you know, equipment manufacturer. So I have a  
15 question broadly on the standard in terms of why the  
16 deviations in the standard compared to IEEE 2800  
17 language, which has been widely accepted in the  
18 industry with the high balloting rate. And there's  
19 also about to be a test procedures, IEEE 2800.2 that's  
20 going to come for the standard. Why deviate from the  
21 language of IEEE 2800, which is widely accepted in PRC-  
22 029?

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

12 MR. PATTABIRAMAN: So but in terms of compliance,  
13 you know, 2800.2 also offers a variety of test  
14 procedures. I'm not sure if there's going to be a test  
15 procedure that comes for PRC-029, but the strength of  
16 2800 is that it offers these kind of test procedures  
17 which different people can study and comply -- and at  
18 least study compliance with, whereas deviating from  
19 2800 language -- for example, there is a language for  
20 phase jump that says that, you know, 25 degrees but  
21 initiated by a non-fault, you know, that kind of  
22 language was not there in 2800. There are small



1 changes like this throughout the standard, including  
2 the frequency Ride-through requirements. So I'm just  
3 curious on what the thoughts of the Standard Drafting  
4 Committee are on that.

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

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

20 MR. PATTABIRAMAN: Thank you.

21 MR. WANG: Yeah. For this one, I think two parts  
22 I address. Yeah. For the 29th standard, right? I

1 believe most of the -- especially for the voltage part,  
2 pretty much align with the IEEE 2800 standard, yeah. I  
3 think for frequency part, yes, actually there's some  
4 division, right? So for this issue, I think even for  
5 this -- even within the Standard Draft Team, that's the  
6 ideal -- the approach we adopt so far.

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

17 For the second one, for the -- for the testing  
18 procedure, right? I know the IEEE standard, the 2800.2  
19 is working on that testing procedure. I think it is  
20 still ongoing efforts, right? The Standard Drafting  
21 Team has very closely participate that -- the working  
22 groups. Actually, we just adopt that approach maybe in

1 the future for the -- for NERC standard, right, for 29  
2 or even the future, the revisions, yeah, for sure we  
3 can adopt that approach in the future. But at this  
4 point, I think even for the IEEE 2800.2 is still  
5 ongoing efforts, yeah. So that -- I think I just want  
6 to bring the attention to the team, yeah.

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

13 MR. AL-HADIDI: Even we don't -- we cannot present  
14 information for even the current -- whatever their IEEE  
15 standard, which is the 57 hertz. So the evidence, you  
16 don't have an event because once event or under -- or  
17 once event is very rare event. When it -- when it  
18 happen, you need to have a system, really, which can be  
19 very robust and very reliable to deal with it because  
20 when it happen, there's a blackout. There is really a  
21 big system event to start with. So really, likely the  
22 -- where we are right now in the system, based on where

1 we are and hopefully -- and that's where -- that's  
2 where our standard is moving, at least hopefully, to  
3 prevent us from being to that stage. So no event --  
4 there is no event happen to support even any frequency,  
5 even 57 hertz, which is there in IEEE standard. It was  
6 -- we cannot -- we have no event to support that in  
7 overall system. Thank you.

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

22 MR. AL-HADIDI: Let me see if what -- if I

1 understand your question about the reaction of the IBR  
2 or to -- how to recover from the frequency itself, and  
3 that's why the six second was giving the IBR time to  
4 respond to the frequency and try to -- because it has  
5 some time response. And in our standard, we did not  
6 come with a performance requirement, so it could be  
7 performed within four second, five second. It's much  
8 faster than synchronous machine to respond to the  
9 frequency event, so hopefully that in the future will  
10 be able to recover the frequency much faster. That's  
11 why we thought the six second itself is the time where  
12 it give enough time for the IBR technology to inject or  
13 remove power from the system to respond to the  
14 frequency event itself. I'm not sure if I got your  
15 question. Sorry if I did not get it.

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

20 MR. AL-HADIDI: Yeah.

21 MS. JONES: So I'm just wondering consideration  
22 for bands that are more accustomed to the dynamics of

1 an interconnect versus just a broad, no matter where  
2 you are, this is what you need to do because there is  
3 some benefits to having it tailored in that way. You  
4 know, when you look at the events in the East versus  
5 the Western interconnect, the evidence is very distinct  
6 on where the concentration of some of those misses  
7 were, which are primarily contributed to settings,  
8 which is human error versus not being able to perform  
9 enough. Was just kind of curious about maybe tailoring  
10 the curves more to interconnection dynamics and  
11 generation mix as opposed to just a one-size-fits-all.

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

1 will generate fundamentally very significant frequency  
2 change.

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

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

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

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

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

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

10 Now, I was part of the Drafting Team for IEEE  
11 2800, and this was discussed pretty extensively, that  
12 standard. IBR-powered electronics do not have that  
13 kind of long duration overvoltage capability. So the  
14 compromise that was established in IEEE 2800 was that  
15 the one cycle filtering requirement was applied for any  
16 protection at the plant level that would -- that would  
17 disconnect the entire plant. For example, if you had  
18 an overvoltage relay, then you would need that kind of,  
19 you know, filtering.

20 However, for IBR units themselves, the standard  
21 did not just give them a blanket exemption. 2800  
22 specified sub-cycle overvoltage Ride-through



1 requirements that individual IBR units had to  
2 withstand, right? So it wasn't a requirement to wait  
3 one cycle before you trip for any overvoltage, but a  
4 more rational requirement for sub-cycle overvoltages.  
5 For example, the IBR unit would need to Ride-through  
6 and overvoltage of 1.8 per unit for one millisecond.  
7 So that's one of the requirements in IEEE 2800.

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

19       MR. AL-HADIDI: We were there first. We have --  
20 it used to be in this Draft Number 1. I believe it was  
21 R4, we're dealing with the transient overvoltage.  
22 However, we were -- basically even -- whatever we see

1 right now in IEEE standard, they are having very  
2 difficulties would -- come with some mechanism how even  
3 to do the measurement and calculation for this  
4 transient overvoltage, and we felt that the industrial  
5 is not in the stage where it could have that -- the  
6 work based the PRC-028 and how the mechanism, how to  
7 calculate it. And it's -- we thought it could be very  
8 difficult to come with way to try to be measuring the  
9 compliance of that event.

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

21 We had a struggle on the technology itself, how to  
22 do the measurement, and that's why we feel there is the

1 best way, try to move away from this requirement,  
2 become very specific, become challenging to meet the  
3 compliance part of it. And that's why we moved away  
4 and to remove it. And we compensated with a filtering  
5 to ensure that if it's a protection -- transient  
6 overprotection, then you have to protect it in this  
7 way. But if it was internal issue, you have the  
8 arrestors. You have different mechanism to deal with  
9 it, able to deal with the overvoltage during -- as a  
10 result of a switching within the IBR facility itself,  
11 so, and that's part of your design. As a design,  
12 that's part of it, but we were mainly concerned about  
13 the system event, and we did not see a way where we can  
14 capture system event for that reason.

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

20 MR. VENKITANARAYANAN: It is at the --

21 MR. WANG: Yes. For PRC-029, we didn't talk about  
22 the unit level. We just look at the POI, right, or POI

1 in -- along with the IEEE 2800. Another issue, we --  
2 the Standard Drafting Team deal with this. For the --  
3 actually even the IEEE 2800.2, Subgroup 2 and 3, we had  
4 very, very lengthy discussions, yeah. If we supply  
5 that at POI, right? So let's do POI, the high set of  
6 transformer. Even the -- even the high set of  
7 transformer endurance, the experience of that high  
8 voltage, right, transient overvoltage, based upon the  
9 BOP of the plant, it's very complex. The issue  
10 actually to reflect back to the terminal, yeah, right?

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

22 MR. VENKITANARAYANAN: Right. I understand, but I

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

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

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

20 MR. AL-HADIDI: You have to Ride-through it. I'm  
21 going to say they have to Ride-through it. They need  
22 to Ride-through it. So it always need responses, same

1 event, and their equipment needs to stay online, and  
2 the standard is not requiring them, as written right  
3 now at least, to provide a frequency support or any  
4 performance. So no performance compliance is just to  
5 maintain -- connect to the system and Ride-through the  
6 event itself.

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

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

1     misunderstood your question or maybe I --

2             MR. HAKE:    So the language in R4 talks about  
3     exceptions for voltage Ride-through --

4             MR. AL-HADIDI:  Yes.

5             MR. HAKE:    -- based on hardware --

6             MR. AL-HADIDI:  Hardware limitation.  Yes, you're  
7     right.

8             MR. HAKE:    Yeah.  So my question is why hardware  
9     limitations only?

10            MR. AL-HADIDI:  Okay.  That also came from the  
11    FERC order.  FERC order stated very clearly that any  
12    voltage exemption need to be based on the hardware  
13    equipment, not the software.  So we tried to -- when we  
14    are constrained with some language, so we -- and we  
15    understood some -- and you're right.  Some software  
16    could be very challenging to deal with, but we  
17    understood by "software," if something could be dealt  
18    with, if it's not really something which you couldn't  
19    update different or upgrade your software, it become  
20    really hardware limitation at that case.

21            So we left it open, what do you -- what you guys  
22    can come with the hardware limitation.  In my opinion,

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

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

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

11 MR. HAKE: Thank you.

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

20 (Applause.)

21 MR. BENNETT: So as they exit the stage, let me  
22 just tee this up for Alex. Our next presentation is a



1 very similar subject, another review of voltage and  
2 frequency Ride-through criteria. So to walk us through  
3 this, this is Alex Shattuck from NERC, and yes, I did  
4 pronounce his last name correctly. So, Alex, please  
5 help us out with this. Do you need a microphone?

6 (Brief pause.)

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

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

22 I figured since we're getting it started here,

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

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

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

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

1 power bill.

2 So next slide, please, Levetra.

3 We'll start with just -- or I guess we'll continue  
4 with talking about what we've seen so far. Right now  
5 we have 10 published major disturbance reports since  
6 2016. That's about 15,000 megawatts, and the last four  
7 years have been about 10,000 of those megawatts, so --  
8 and about twice as many events. So if you look at two  
9 windows of time, we've doubled both size, total size,  
10 and we've doubled the frequency of these events, which  
11 means they're probably -- they're linked a little bit.  
12 The observations point to the fact that they're linked  
13 to penetration of IBR, right? If you look at the  
14 little graph on the bottom left, you can see the  
15 events, right? They're happening in areas that right  
16 now have some of the highest penetration of IBR. Major  
17 disturbances, those reports, those are -- those 10  
18 reports are IBR related. There's been a few more of  
19 those since those last ones are out. We're in the RFI  
20 kind of data collection stage for those.

21 But that's not the whole story, right? There's  
22 also different technology. So the major events so far

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

17 It's not to say that the wind has no risk  
18 associated with it. Just preliminary, kind of off the  
19 top of my head numbers for that, it was something about  
20 80 percent of the multiple thousands of megawatts  
21 unexpectedly tripping off wind in Texas, about 80  
22 percent of those or 90 percent of those were for the

1 exact same reasons that we presented in all of the  
2 solar PV and BES reports. So why are they not showing  
3 up? Well, they're kind of, you know, it could be at  
4 night, right? The faults happen during the day. Maybe  
5 wind isn't operating at full capacity like PV is. If I  
6 have a hundred-megawatt PV plant and a hundred-megawatt  
7 wind plant in the middle of the day, the wind plant's  
8 probably half-ish and the PV plant's at max.

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

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

1 someone brought it up -- PRC-024 four has regional  
2 variances for -- different requirements for different  
3 areas, right? If you look at, you know, the draft PRC-  
4 029 and, you know Quebec's PRC-024 curve, they're  
5 pretty similar, but again, that's for a specific system  
6 with specific needs.

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

1 if you have a good starting point, we can adapt that to  
2 what we need for reliability. And what I did to kind  
3 of help with the rest of the slides and the  
4 comparison --

5 If you go to the next slide, Levetra --

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

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



1 specifically at the maximums in the short timeline.

2 So, I mean, if you look at kind of farther out in  
3 the 200-302nd range, we're not that far off. They're  
4 pretty well aligned. It's just this kind of first six  
5 seconds where we see the massive deviations both from  
6 2800 and from the original PRC-024.

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

9 So y'all stole my thunder a little bit here by  
10 doing your due diligence, which is great, but none of  
11 the major events -- none of the 10 major events we've  
12 released reports on were outside even the continuous  
13 operation bands. And if you look at the little -- the  
14 very small, very skinny yellow rectangle, that is the  
15 worst frequency deviation and time out of all of the  
16 events, and that's Blue Cut in 2016. And you can see  
17 that's well, well within both PRC-024, within the  
18 continuous operation bands, and it's well within both  
19 PRC 2800 -- or sorry -- IEEE 2800 and the draft PRC-  
20 029.

21 So this kind of shows us that for those types of  
22 events -- you know, keep in mind that these disturbance

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

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

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

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

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

19           The last slide -- you don't have to go back --  
20 what the last slide said -- I said nearly all  
21 frequency-related tripping was due to mis-operate --  
22 not mis-operations, but incorrectly set parameters,

1 instantaneous measurements. None of those -- I wrote  
2 "nearly" on the slide to cover it, but none of those  
3 were based on criteria. You can see on the last graph,  
4 too, that they weren't anywhere close to the criteria.

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

18 So all of this can hopefully -- I'm trying not to  
19 get into too many details. I want the panelists to  
20 tell us all the things from their mouths, different,  
21 from them. So this is just to show that if we look at  
22 our data, it's not a ticking time bomb. It's maybe a

1 time bomb in construction, right? It's a -- it's not  
2 an immediate tomorrow problem, but it's maybe a  
3 something we should focus on moving forward. But  
4 again, both things we're proposing, or, you know, we're  
5 talking about through all the comments, the main topics  
6 we're talking about are 2800 and PRC-029. Both of  
7 those would have, you know, written through these  
8 events.

9 So if you go to the next slide, please.

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

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

13           So looking at the data we're receiving in our  
14 Level 2 alerts, both modeling and IBR performance, and  
15 kind of the fact that none of the 15,000 megawatts that  
16 tripped offline were predicted in the model space, I  
17 don't know at the current moment if the industry's  
18 ready to say, hey, here's a study I'm going to hang my  
19 hat on that says here is the level of frequency Ride-  
20 through I can get my system to do and use it as a  
21 benchmark event, right? We need to improve our  
22 modeling, improve our studies, improve our

1 parameterization, and then maybe we can trust that for  
2 something as important as setting these things.

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

13       And if you go to the next slide, please.

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

22       So this is a recommendation from our Level 2 alert

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

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



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

7 So next slide, please.

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

1 it's 10 percent, maybe you can live with that, right?

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

14 That's something that OEMs will talk about, I'm  
15 sure, is the development cycle for products, right?  
16 Usually requirements inform design of IBR, right? We  
17 used to ask for requirements all the time when I was at  
18 the OEM, you know, please tell me what you want so I  
19 can build it and give it to you. The problem is that  
20 takes a while, right? And nd if you keep changing  
21 things, right, if we -- if every other year we have a  
22 new kind of proposed thing, then it gets kind of hard,

1 right, to make sure we're designing things. And if you  
2 keep resetting the cycle every couple years, we're just  
3 kind of, you know, we're wasting money, you know, IBRs  
4 become more expensive, power becomes more expensive,  
5 and it's just kind of a big technical thing the OEMs  
6 will really probably correct me on and expand upon.

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

20 And the last bullet here is that you kind of get  
21 some diminishing returns, the capability extremes, and  
22 I kind of referenced it a little bit earlier, is if,

1 you know, say we're all buying a car. The speed limit  
2 is 50. All the cars I can buy go 50, right? But then  
3 someone says, well, you have to have a car that can go  
4 a hundred miles an hour. I'm not going to buy a car  
5 that can go a hundred miles an hour if the speed limit  
6 is 50, right? So the products are going to be designed  
7 towards what about their requirements are, and if you  
8 really expand those to the bounds of equipment  
9 limitations, you know, it might be very expensive to  
10 get that last extra hertz, right, or extra hertz of  
11 criteria, an extra couple seconds of time.

12 So really, that goes back to the effective and  
13 efficient and reasonableness thing, right, is probably  
14 if we set some parameters very wide, in a few years  
15 after the development cycle, people could meet it, but  
16 what does that mean? Is that, like, a \$10 million wind  
17 turbine now because, you know, it costs \$2 million to  
18 get it to 63 hertz, but, you know, 68 might be some  
19 crazy amount of engineering or design and all that  
20 extra work. So the balance here is very important, and  
21 it starts with the needs. Basically, it starts with  
22 the needs, and then you have to balance it with what

1 can I do and what can I do for some reasonable amount  
2 of, you know, effort, resources, that kind of thing.

3 Next slide, please.

4 So for new equipment, so I'm going to talk about  
5 new equipment, and then we'll go back to legacy stuff.

6 So for new equipment, criteria need to be reasonable  
7 when compared to current and future capabilities. So  
8 if everybody's designed for one thing right now and we  
9 go 10X that, it might not be reasonable, right? If  
10 everything's been designed for something, when we  
11 change that criteria to expand it, we have to make sure  
12 that it's at a level of expansion that keeps the grid  
13 safe while also making sure that we're not putting --  
14 we're not going to make things cost an extremely large  
15 amount of money, right, because we're trying to meet  
16 these future capabilities and that kind of stuff.

17 So if criteria are outside of equipment  
18 capabilities, like we're -- we know we've gotten some  
19 comments about from our written comment submittal, we  
20 need lead time, or the industry needs lead time, right?  
21 It takes time to build a new inverter. It takes time  
22 to do research and testing and all that type of stuff

1 to be able to build something that you can sell to  
2 someone to install, and they'll still give me input,  
3 but probably five-ish years, you know, a ballpark.

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

15 So the bottom bullet is in red, and we're leading  
16 into the panel this afternoon, but input from  
17 manufacturers is crucial, right? Those are the folks  
18 who know what's in the box, right? They know what's in  
19 the box, they know how you got to what's in the box,  
20 and they know what's possible within the same box and  
21 what it means to build a brand new box, right? So  
22 their input is very crucial to kind of do the balancing

1 act that we need to do for the efficiency part of that  
2 Venn diagram.

3 So next slide, please.

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

16 So hardware based has kind of two buckets, right?  
17 It could be small, hardware-based retrofits of  
18 equipment, maybe a new transformer, maybe something --  
19 you know, a new smaller piece of equipment that's going  
20 to be more expensive than a software-based solution,  
21 but it's definitely going to be cheaper than repowering  
22 the whole plant, right? So that kind of nuance in the

1 timeline of resources necessary from left to right,  
2 that's going to be very crucial to hear from OEMs,  
3 right? What is a small hardware based? What are your  
4 thoughts about doing that? Maybe the generator owners  
5 could answer that. What are you comfortable with? You  
6 know, at what point does a retrofit turn into a  
7 repower, right, and at which point does that mean  
8 you're not going to operate your facility anymore?  
9 Those are the types of balance and things that we need  
10 to hear from industry and from the OEMs to give us this  
11 information so the Drafting Team can update the  
12 language to make sense for all of us.

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

18 So next slide, please.

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



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

12 But the third bullet here is that exemptions could  
13 allow legacy equipment to remain connected while  
14 maximizing capabilities, but then there's like a giant  
15 burden of proof for that, right? It's going to take  
16 more than someone saying, my manufacturer said they  
17 can't, right, and they attested to this, right? That's  
18 probably not sufficient as far as documentation, right?  
19 We're looking for things like show us a curve that, you  
20 know, shows you're going to damage something. Give us  
21 documentation that your software-based protections  
22 aren't sufficient, right? New software can't go into

1 old equipment maybe sometimes. Maybe it's firmware  
2 limited. Maybe they're already set at their maximum  
3 capability, right?

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

19 So next slide, please

20 So we do have some data. The data is from the  
21 Level 2 alert for IBR performance. Keep in mind this  
22 was just solar PV and BES, and I realize that the

1 numbers are super small. So the first piece of the  
2 data is that about 70 percent-ish of those folks who  
3 gave us their frequency protection settings said that  
4 they were not based at the maximum hardware capability.  
5 So we have reported data that says about 70 percent of  
6 the IBRs out there right now can do some sort of  
7 software-based something. Is that software based  
8 something big enough to meet PRC-029? The  
9 manufacturers will tell us. So we do have some room to  
10 make some adjustments.

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

18 So if you look at this thing, this is the -- all  
19 of them are within maximum capabilities, and we start  
20 with PRC-024, so this is the small blue chunk. Seven  
21 percent of what's been reported to us is within PRC-  
22 024, so current requirements, about seven percent are

1 reported inside that. The next biggest chunk, about 32  
2 percent of those inverter settings are within 2800,  
3 which means that, if the data is true, right, if the  
4 data they gave us is right, and they're at their  
5 maximum capabilities and that's what they're at, then  
6 we got about 30 percent of what's out there right now  
7 within 2800, which is somewhat actually in line with  
8 the data we got back from some of the folks who  
9 submitted that to us in writing with real numbers.

10 So the big chunk is things that are within PRC-  
11 029, right? Sixty-one percent of the total maximum are  
12 within PRC-029, and that makes sense, right? As you  
13 make the curves wider, fewer and fewer equipment are  
14 going to be able to meet it, right? So as you make  
15 things wider, we'll have to -- we're going to have to  
16 deal with a large number of potential hardware-based  
17 solutions. And what that number is and where we land  
18 in the spectrum of curves is going to be dependent on  
19 what we can do, what we're happy with not meeting  
20 criteria and what we do with those things.

21 So this is just to kind of quantify and to show  
22 that it's very important to pick the right, you know,

1 criteria so that we don't end up with, you know, a  
2 circle that says a hundred percent of equipment can't  
3 meet it, right? We don't want that at all, but we got  
4 to pick -- the onus is on us the Drafting Team and as  
5 an industry to pick some criteria that we are happy  
6 with the things meeting and happy with the things that  
7 can't meet. And potentially, like we've discussed, you  
8 know, documenting limitations and providing that as  
9 evidence to be used for drafting decisions, right, and  
10 that kind of stuff.

11 So next slide, please.

12 I'm going to go very quickly so we have some  
13 questions time. So manufacturer challenges, they're  
14 going to talk about it in a moment or after lunch. So  
15 new IBR, what criteria to build for? How do you  
16 procure test locations? Long lead times. And again,  
17 at the extremes, right, the capabilities get really  
18 expensive, right? The extremes of anything get really  
19 expensive. For legacy equipment, hardware limitations,  
20 software solutions might not be sufficient, and legacy  
21 equipment was tested with applicable criteria in mind,  
22 right? So there's actually a decent number of stuff

1 out there that we don't know what the -- we don't know  
2 what it can do because it was tested for PRC-024 or  
3 slightly more than PRC-024.

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

15 Next slide, please.

16 So industry challenges: deciding which equipment  
17 will be needed to meet new requirements, getting  
18 evidence that equipment can or can't meet,  
19 communicating technical details to everybody. How do  
20 you do that, how do you post them, what are you  
21 posting, and that's for new equipment. For old  
22 equipment, how do you manage stuff that can't do it,

1 right? How feasible is the software solution? How  
2 hard is it to get data? Apparently very hard. We  
3 learned through our two Level 2 alerts, both of which  
4 had the first ever extensions of deadline, it's hard to  
5 get data. And we were asking for things we're talking  
6 about today, protection settings, and we gave about 90  
7 days, a hundred days for that, and we had difficulty  
8 getting protection settings in that time.

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

18 So next slide, please.

19 So key takeaways, another big red bullet at the  
20 bottom. I've said all this before, but  
21 manufacturer/industry input, extremely important to  
22 know what we can and can't do. We are recommending or

1 we have recommended for eight years now to maximize  
2 your Ride-through capability. Documentation that's  
3 validated and accurate is difficult to obtain but will  
4 be critical moving forward.

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

8 (Laughter.)

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

10 (Laughter.)

11 MR. SHATTUCK: We can talk later.

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



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

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

12 MR. SHATTUCK: Uri.

13 MR. PATEL: -- Uri, right?

14 MR. SHATTUCK: Mm-hmm.

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

20 MR. SHATTUCK: Mm-hmm.

21 MR. PATEL: And actually, NERC System Protection  
22 Control Working Group ended up writing a white paper

1 saying, well, look, we cannot design PRC-024 or  
2 PRC-006, which is automatic under frequency load shed  
3 standard to something that happens over tens of  
4 minutes. Those two standards, 006 and 024, are for  
5 things happening in matter of seconds where operator  
6 has no time to blink, right? So anyhow, that was good  
7 comparison, but I think it's a little bit of apples and  
8 oranges.

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

17 (Laughter.)

18 MR. PATEL: And I'm also proud -- I'm also proud  
19 sometimes saying that, you know, we didn't know what is  
20 the right answer, so we flipped a coin five times and  
21 decided which way to go. But so when we wrote IEEE  
22 2800, what we did was, well, we don't want to write a

1 standard that is based on most stringent PRC-024,  
2 right? We wrote a standard that met two largest  
3 interconnections, assuming that for two other regions,  
4 there might be a reason to require slightly more Ride-  
5 through capability, and those two regions will write  
6 their own variance of it, right? So I think that's the  
7 option we could consider is can we take different Ride-  
8 through capability for different regions. I guess that  
9 was not a question, a comment. Thank you.

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

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

21 MR. SHATTUCK: Mm-hmm.

22 MR. KAPPAGANTULA: As an example I could give you,

1 just to make some software changes on one of our  
2 battery projects, we got a code of nearly a million  
3 dollars, right? And so when we're -- when we're  
4 talking about something is cheap, it's probably going  
5 to be relative --

6 MR. SHATTUCK: Mm-hmm.

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

19 MR. SHATTUCK: Yeah.

20 MR. KAPPAGANTULA: The other piece also is when  
21 you're changing some parameters, that may not  
22 necessarily be a software change. So there's a lot

1 that goes into it, so let's not uniformly say that the  
2 idea of, you know, we can make a few tweaks here in the  
3 software and that's going to just do the job. It's not  
4 true. That's what my technical experts are saying.

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

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

12 MR. SHATTUCK: Yeah.

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

14 (Laughter.)

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

17 (Laughter.)

18 MR. ROGERS: Yeah. So real quick question. You  
19 showed us the curves that had the, you know, frequency  
20 excursion events that we've witnessed within them and  
21 plotted, and we touched up against one of them. So  
22 that was, you know, the actual, you know, what we

1 witnessed with the frequency. But another part of the  
2 -- you know, one of the contentious points of this is  
3 the rate of change of frequency.

4 MR. SHATTUCK: Mm-hmm.

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

20 MR. SHATTUCK: Yeah, great question. I don't  
21 think I have that data. I don't think we have that  
22 recorded data. We have the frequency traces, but it's

1 that, like, SCADA data granularity, right? So that's  
2 -- a specific data point we don't have at the moment.  
3 The only kind of information data points we have on  
4 ROCOF is -- that's rate of change of frequency for  
5 everyone else -- is, you know, international building  
6 standards or equipment standards that are used in a lot  
7 of IBR equipment facilities, right, the non-IBR pieces,  
8 the transformers, the other pieces of equipment. The  
9 data point we have for those are the, you know, the  
10 standardized ROCOF requirements, so, like, that's the  
11 only thing we really point to because we don't have the  
12 data from the actual events.

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

19 MR. SHATTUCK: Great question, yeah. So I would  
20 -- I would like to point everyone to NERC's published  
21 that modeling guidance, which says that if you want to  
22 do something like a detailed study, right, an

1 interconnection study, a study on your own facility to  
2 evaluate your design, for a local reliability study, if  
3 I'm Texas -- oh, that's a bad example -- that's a bad  
4 example -- if I'm New York studying New York, we are  
5 recommending user written models, equipment-specific,  
6 manufacturer-specific models, we're aware, right,  
7 obviously that many folks can't submit them. They're  
8 not allowed. But I would point also to FERC Order  
9 2023, which says to submit both the standard library  
10 model and a user-defined model. And, you know, we  
11 totally recognize that if we're using a standard  
12 library model, we're not going to be able to represent  
13 most of these things we're talking about, specifically  
14 the detailed protections and that kind of stuff.

15 So we're recommending to use those more detailed  
16 models specifically for what was in the question,  
17 right? We know that what's out there is insufficient.  
18 Nothing's been captured, right? Nothing's been  
19 predicted, none of the major events. There is --  
20 that's why we have a modeling alert out right now,  
21 right? The idea is to raise the floor of study work-  
22 through, you know, proper use of more detailed models



1 where appropriate, not to say that standard library  
2 models have no place anywhere. But if you care about  
3 the result, if you want it to be accurate, if you want  
4 to be able to take that study and put it into a product  
5 or vice versa, you've got to use something more  
6 detailed like a -- usually a defined equipment-specific  
7 model.

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

1     happen.

2           MR. SHATTUCK:   Will do that.

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

5           MR. SHATTUCK:   Thank you.

6           MR. BENNETT:   Great presentation.   Very  
7     informative.

8           (Applause.)

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

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

20           (Luncheon recess.)

21           MR. BENNETT:   Okay.   So I'm showing 1:00 here, and  
22    it looks like we have most everybody back here in the

1 room. So for our online participants, I think we're  
2 getting ready to start.

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

10 (Sound checks.)

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

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

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

22 MR. COOK: Yeah. Could we have the panelists,

1 starting down at that end, please introduce yourself?  
2 Tell us a little bit about yourself and who you  
3 represent today, again, keeping an amount -- I'm sorry  
4 -- keeping in mind that we are time limited, so.

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

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

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

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

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

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

18 So question one says, do you anticipate challenges  
19 with your equipment meeting the voltage Ride-through  
20 criteria as specified in Attachment 1 of the draft PRC-  
21 029, and there are three subparts to that. First of  
22 all being, if you do so, do you have an estimate for

1 how many products will be affected? Second part, how  
2 does the estimate change when considering IEEE 2800?  
3 Third part, how does the estimate change when you  
4 consider PRC-024 boundaries? So I'll direct that  
5 question first to Dinish.

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

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

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

4 MR. SCHMIDT GRAU: Repeat that one.

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

8 MR. SCHMIDT GRAU: Yep.

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

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

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

20 MR. KARPIEL: So future, current, previous  
21 generations of our inverter stations, I have no  
22 problems with the voltage Ride-through. The legacy

1 stuff that's going back 10 or so years, clips a little  
2 bit of a corner on one of the Ride-through corners, but  
3 then with the exemption, it shouldn't be a problem.

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

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

8 MR. COOK: Yes. Voltage, yes.

9 MR. KARPIEL: Yes.

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

11 MR. KOERBER: Similar to my colleagues here, I  
12 think we have to really split this between new products  
13 that are under development and the installed base. For  
14 new products, plants are generally aligned with IEEE  
15 2800, so we're evaluating what's the difference. What  
16 impact does that have for the installed base? We do  
17 expect that the majority of the installed base does not  
18 meet these voltage Ride-through curves. Some cases  
19 might be close. In some cases with a project-specific  
20 evaluation, voltage drops across the collector system,  
21 it might be possible to meet it, but on paper and  
22 curves taken strictly as stated, we do expect that the



1 majority of the installed base does not meet those  
2 curves. That's on the curve.

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

10 MR. COOK: Thank you.

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

1 MR. COOK: Okay.

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

4 MR. COOK: Thanks.

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

7 MR. COOK: Thank you.

8 MR. SHATTUCK: So I guess most of us are wind,  
9 right, here. So we're missing our estimate  
10 participant, but I guess, Dinish, since you're the --  
11 (Side conversation.)

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

22 MR. KARPIEL: So for PV and BES, battery energy

1 storage, it's both, right? There's a hardware  
2 limitation as to how long the holdup -- the backup for  
3 the communications and everything can withstand. So  
4 whether they're using a battery, a UPS, a super cap, or  
5 whatever they're using to have that buffer installed,  
6 so that's a hardware limit -- that could be a hardware  
7 limitation.

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

19 MR. SHATTUCK: Thank you.

20 MR. PATTABIRAMAN: Just to add to it, yeah, the  
21 same. It's pretty similar reasons. It's both software  
22 and hardware for at least the Ride-through curves by

1 themselves. In terms of other requirements that are --  
2 I think the gentleman from GE also brought this up  
3 before -- the instantaneous overvoltage protection,  
4 having one cycle of filtering is something our hardware  
5 cannot do. You know, IGBTs have very limited voltage  
6 handling capability, so having a one-cycle requirement  
7 significantly exceeds the capability of our products.

8 MR. SHATTUCK: Thank you.

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

18 And also, when we are talking about software  
19 parameter parameterization, we cannot forget about the  
20 models, right? Every time the software gets  
21 parameterized or firmware get updated, corresponding  
22 model is expected to be provided, and rightfully so,

1 right? For our legacy turbines that have been  
2 operating for 20 years and no longer in design phase,  
3 models were provided when they were first commissioned.  
4 I don't think anybody actually started using those  
5 models and providing feedback to us, so we saw no  
6 reason to update those models. Like, for the legacy  
7 turbine, we do not have any reason to keep them updated  
8 since we never got a feedback on a -- if there is any  
9 need to be updated. So all of a sudden asking not only  
10 to change the parameters, but also provide the model in  
11 a reasonable time -- updated model in a reasonable time  
12 that works with today's simulation environment, it's  
13 going to be a huge challenge. I mean, it can be done,  
14 but it's going to take a lot more than six month or a  
15 year.

16 We have -- we currently have closer to 15, 16,000  
17 units installed, right? Each of those turbine might  
18 not have the same firmware. I know it. They don't,  
19 right? And also, our customers or the assets owner do  
20 have some flexibility on changing the parameter as they  
21 deem necessary, you know, based on their field  
22 experience or what have you. That information we do

1 not have. So there is significant challenges just to  
2 provide a -- you know, to meet the new standard with  
3 those software or, you know, hardware parameterized,  
4 and I don't want anybody to forget that, you know?  
5 Yeah, you can -- we can do it. Parameterizing software  
6 can be done in, let's say, a year, but getting our  
7 corresponding model will take a lot more than that,  
8 yeah, especially validating as well.

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

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

1 right models for that evaluation.

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

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

22 MR. KARPIEL: And let's not forget the medium

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

16 MR. DAHAL: I also want to bring attention to the  
17 concept of repower, right? Like, we're talking about  
18 this and talking about repower. The repower that we've  
19 seen so far have been efficiency driven, right? So  
20 repower happens because you want to get more power out  
21 of the old turbine, not necessarily the electrical --  
22 new set of electrical performance. We retain the main



1 brain converter/inverter system, cooling system as it  
2 is, just change the rotor from the wind side. So just  
3 the term, "repowering," doesn't mean what you guys are  
4 thinking about repowering, you know. Oh, you repower,  
5 you get new set of performances from them, and that's  
6 not true at all. The market is not there for that to  
7 happen. The repower project that we have done so far  
8 has been purely mechanical repower, and it is very  
9 essential to consider that as well.

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

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

20 MR. PATTABIRAMAN: Just answering the question on  
21 the balance of plant equipment. There are surge  
22 registers that are also included in the design of a

1 typical IBR plant. They're typically located at the  
2 end of a feeder through wide overvoltages, absorb  
3 overvoltages, and so on. And the problem is that these  
4 sites are already designed with certain energy levels  
5 for these protectors and surge protectors, and any  
6 level of higher overvoltage could physically damage  
7 these protectors. But that kind of also includes  
8 instantaneous overvoltage, like I said earlier, is  
9 that, you know, having a one-cycle delay could  
10 basically be the difference between damaging and not  
11 damaging these arresters.

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

22 So we'll jump into the next question. Again, it's

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

9 MR. KOERBER: Yeah. And for us, there's about --  
10 preliminary analysis looking into this, we estimate  
11 there's about 20 gigawatt of installed capacity. These  
12 are some of the oldest units, substantially before  
13 2014. That would not meet the frequency Ride-through  
14 requirement if comparing against the S-design curve.  
15 What it would take, not in a position to comment on  
16 this. It's about 20 gigawatts installed capacity, and  
17 the answer really doesn't change whether it's IEEE 2800  
18 or PRC-024.

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

21 MR. KOERBER: Yeah, legacy.

22 MR. SHATTUCK: We'll go down the line. Same path

1 forward, yeah.

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

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

1 into consideration of design as there's no suppliers in  
2 the industry that can meet that today.

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

5 MR. SCHMIDT GRAU: I will find it.

6 MR. SHATTUCK: Okay. Thank you.

7 MR. DAHAL: I second Vesta's response to that.  
8 Our legacy turbines cannot meet PRC-029. We have not  
9 considered PRC-029, those curve for six second in our  
10 new design either. So as of today, we have no product  
11 that will meet -- that will comply with PRC-029  
12 frequency Ride-through in its entirety. Regarding IEEE  
13 2800, we meet our newer turbine and our legacy turbine  
14 with some software and hardware modification, mainly  
15 software. We will be able to meet IEEE 2800.

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

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

19 MR. SHATTUCK: Okay. Yeah.

20 MR. DAHAL: Type 2 and Type 4, yes. And then our  
21 restrictions comes from -- for whatever was mentioned  
22 already. We do not have motors that we can source that

1 will be able to Ride-through all the ancillary  
2 equipment, you know. I think if you look at what other  
3 IEC requirement, IEC 60034, IEEE 50-1, they all have  
4 plus-3/minus-5 requirement for these motors, and that's  
5 what -- you know, that is in line with IEEE 2800, and  
6 that's what our design philosophy is. And let me also  
7 add our -- it'll probably come later, but design cycle  
8 -- design-to-market cycle is five years for wind  
9 turbine. So any new standard that has that much of an  
10 effect needs to be given at least five years, if not  
11 more time, to be applicable. And if it's, you know,  
12 cost prohibitive or anything like that, then that's  
13 going to be another issue.

14 MR. SHATTUCK: Thanks.

15 MR. PATTABIRAMAN: So for older TMEIC inverters,  
16 especially thousand-word inverters and before, we have  
17 hardware limitations in terms of what can be done in  
18 the order. So the typical design that was used was  
19 plus or minus 3 hertz. During the time, 5 percent  
20 change in frequency was the maximum capability of the  
21 equipment. So we may have hardware limitations, such  
22 as, like OX equipment, fans, or whatnot for cooling may

1 have some hardware limitations. We are still exploring  
2 that. But even on the software side requirements,  
3 like, having 5 hertz per second were not part of the  
4 design criteria back then, and it would require a  
5 significant change in software to achieve 5 hertz per  
6 second. It's not a simple parameter change that it  
7 could do or a simple software update. There's  
8 extensive design.

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

22 For newer inverters, yes, they have wider

1 capability to meet some of these wider frequency  
2 requirements. But we still -- not from OEM  
3 perspective, but from a power system perspective, we  
4 still don't see the need to have these wide  
5 requirements, especially given that none of the  
6 existing events or none of the existing studies have  
7 pointed to any evidence of wider frequency  
8 requirements.

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

11 MR. SCHMIDT GRAU: Forty gigawatt.

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

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

17 MS. CALDERON: Yes.

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

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



1 MR. SHATTUCK: We got them, I think.

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

9 COURT REPORTER: (Off mic comment.)

10 MR. COOK: God bless you.

11 (Laughter.)

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

18 MR. KARPIEL: There would have to be some kind of  
19 a declaration, obviously, from the manufacturer stating  
20 that you don't meet this requirement or that  
21 requirement due to this hardware limitation, this  
22 software limitation. We're not going to share our IP,

1 obviously, but we do need to provide indication of what  
2 portion of the standard that it's not going to meet,  
3 why it's not going to meet that rather -- if that's --  
4 this unit doesn't have enough buffer in that -- the  
5 buffer doesn't have enough energy to Ride-through zero  
6 volts for X seconds, this is why there's no space  
7 available to install a UPS or something of that nature.  
8 It's going to be basically our responsibility to put  
9 together a declaration, like I said, and with examples,  
10 curves, graphs pointing to certain specific hardware  
11 components that are not available for -- because  
12 they're not available on the market to provide back to  
13 the GOs and then back to the TOs.

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

19 MR. KARPIEL: We would probably do it on a  
20 specific request because the inverters themselves have  
21 different hardware configurations. We'd have to go  
22 look at that specific project's build to understand

1 what is or is not included in that machine and what  
2 generation it is so that we can accurately provide  
3 detailed information regarding the equipment that's in  
4 that plant.

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

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

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

1 enough just with the document. We also need to do the  
2 adequate design analysis for it.

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

18 We will provide the capability of the turbine.  
19 This is what the turbine can do. Here's the testing.  
20 Here's the evidence that we have. But showing that  
21 something can't be done, it's a risk, but also it  
22 involves opening up our entire design process. What

1 are our design limits? What are our margins? There's  
2 a lot of IP involved, and we don't see us being in a  
3 good position to provide documentation on capabilities,  
4 on limitations beyond what's the stated, published  
5 product-level capability. It's speculation, and it's a  
6 very unbounded problem. There's a lot of things you  
7 can do with modern software -- modern software systems  
8 if you had all the time and all of the funding in the  
9 world to solve this problem.

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

18 MR. DAHAL: Yeah, I completely second that, and I  
19 would like to add that each turbine needs to be  
20 evaluated on its own. We will not be able to provide a  
21 -- forget about the fleet level, right? We have 20  
22 models so far with various power-rated power output

1 from them. So we won't be able to provide, let's say,  
2 20 different statements saying our -- this fleet can do  
3 this. It has to be per turbine based, as has been  
4 indicated, seeing what is inside the turbine, what  
5 component was resourced, and what kind of documentation  
6 we ourselves have that can be used to provide you all  
7 with what you need. So that exercise, again, will be  
8 very timely. You know it will take time.

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

1 MR. COOK: Thank you.

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

10 MR. SHATTUCK: Go ahead.

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

15 MR. SHATTUCK: Thank you, and I guess the next  
16 question bled into this one, but -- and we'll start  
17 from Thomas and come back down the line. But I guess a  
18 follow-on to that last question is -- and I think the  
19 answer is -- y'all touched on it, but, you know, what  
20 documentation are y'all comfortable with sharing,  
21 right, with someone like the -- a transmission planner  
22 or NERC or, you know, your utility or entity, because

1 it sounds like there's a clash of IP and sharing  
2 information, right? But we also have to make sure that  
3 BPS is reliable, right? So there's got to be some  
4 maybe middle ground of IP and/or justification or  
5 something we can all be comfortable with on both sides,  
6 but I'm interested to hear what y'all are comfortable  
7 with and what that might look like. Yeah, Thomas.

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



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

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

13           MR. KOERBER: Yeah, very similar comments. We're  
14 generally comfortable sharing existing product  
15 capabilities. This also includes existing optional  
16 features that operators may or may not have used and  
17 implemented on their turbines. This is fully-designed  
18 capability, product specifications, comfortable sharing  
19 this. We also have very consistently provided, let's  
20 say, indicated fleet demographics as part of NOGRR245  
21 for ERCOT. How many turbines are impacted by what  
22 curve? And we generally plan to do so to help you kind

1 of run scenarios. What's the impact? What would  
2 happen if we do that, generally reasonably, and we plan  
3 to continue doing that.

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

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

21 Like, when it comes to unit model validation like  
22 ERCOT requires for the new project, we provide the

1 report to go with those as well. But any standard  
2 needs to adequately address what kind of test needs to  
3 be completed, in what manner, in what setting, with  
4 what margin, and what kind of report are they expecting  
5 at the end of the day. But it can't be open-ended and  
6 ask us to, you know, provide all the -- all the, you  
7 know, documentation when there is -- the requirement is  
8 so vague. And obviously we can't speculate on the  
9 future requirement. Nothing gets designed anticipating  
10 the future needs. You kind of touch bases whenever  
11 it's designed.

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

1 MR. SHATTUCK: Thank you.

2 MR. PATTABIRAMAN: Very similar comments. The  
3 documentation we can share is often based on our  
4 judgment internally and what the capabilities of the  
5 inverter are. Even with an NDA, the information we  
6 share is often very limited because of IP issues. So  
7 yeah, that's essentially what we can share.

8 MR. SHATTUCK: Thank you. Before we go to the  
9 next question, maybe suggest that the other panels, we  
10 kind of hit on this topic and kind of understand the  
11 other side of what would -- what they would be  
12 comfortable with -- well, whoever they're representing  
13 would be comfortable with getting, and, like, you know,  
14 feelings on NDAs and all that kind of stuff and  
15 process. So, like, we heard you, all sides, and now  
16 maybe next panel we can hear from what we're  
17 comfortable with as evidence, and maybe we'll meet in  
18 the middle. We can go to the next question now.

19 MR. SCHMIDT GRAU: Sorry. Maybe quick comments on  
20 the evaluation. I think that's really key for this as  
21 well because we have seen a lot of this evaluation for  
22 it done in the past with PRC-024. People basically

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

15 MR. SHATTUCK: Thank you.

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

20 MR. KARPIEL: So we had one number here as five  
21 years. It could also last longer. I also think it's  
22 important to understand is it economical to redesign a

1 complete turbine. If we have designed a turbine today  
2 and it'll be installed five to 10 years from now, if  
3 that platform gets completely obsoleted and we cannot  
4 sell it, where does the investment money come to  
5 redesign? So we're going to hit a race that we cannot  
6 comply with, that every time we have a new standard, we  
7 have to obsolete the old turbines. So it's really  
8 important for us that we also get some money back to  
9 keep investing and improve the products so we don't go  
10 into that race for it. So five years and maybe killing  
11 the platforms if the standards go in this direction.

12 MR. KARPIEL: So I've been in manufacturing a long  
13 time, and you have to understand that we're all lean  
14 manufacturers, not only from a manufacturing supply  
15 chain standpoint, but also a resource standpoint. We  
16 have a roadmap, and our resources are currently booked  
17 up for the next couple of years, if not more, going --  
18 looking at next-generation products, operations, you  
19 know, the sustaining engineering that happens on the  
20 existing equipment, future generations, new designs.  
21 And then if we have to introduce something new, where  
22 does that go in the schedule? You've got design,

1 you've got testing, you've got model validation and  
2 certification that has to happen, so minimum five to  
3 six years on a new design.

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

17 But it's really not just the internal reasons.  
18 They are -- that's on us to overcome. It's a question  
19 of investment, and it's also external reasons. And on  
20 one hand, let's say, supplier relationships for  
21 products that we no longer manufacture, we may not be  
22 in business anymore with the suppliers of those sub-

1 components, which also have software, which have  
2 firmware, which we have to reactivate, which just like  
3 you are asking us the questions, what it takes, they  
4 will come back to us and say, hey, if there's no  
5 business, if you don't need to do a retrofit, we are  
6 not supplying to you actively anymore because we're not  
7 shipping those products anymore. It's just a whole  
8 supply chain that may have to get rebuilt up to even  
9 work through the engineering.

10 And then the second external kind of reason that  
11 makes this difficult is in our relationship with  
12 customers. We manufacture these turbines. We don't,  
13 in many cases, operate them. They've been operating  
14 10, 15 years. Self-performing customers, they have  
15 their own services teams. They have -- may have  
16 retrofit those turbines. They may have replaced  
17 electronics. They may have replaced actuators. We  
18 don't know what state they're in, and they will ask us  
19 to guarantee that they meet the Ride-through  
20 performance if we do a -- if we do a retrofit. They  
21 will also want a warranty that whatever new software,  
22 whatever new component we install actually works and



1 doesn't impact the rest of the turbine, as I mentioned,  
2 complex mechanical, electrical software system.

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

16         MR. DAHAL: I'd also like to highlight the fact  
17 that turbines today has not been like -- you know, we  
18 do not design a new product every five years, right?  
19 There've been accumulation of the experiences gathered  
20 throughout 15, 20 years, right, what worked in year  
21 one, what didn't work. We base the design on those  
22 components, like our experience, what failed on the

1 field, what do we need to improve. So we are very  
2 excited to participate in IEEE 2800 and very static,  
3 you know, when it was approved.

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

18 So I guess everybody needs to sit and think, like,  
19 what is the benefit that we're going to achieve? Like,  
20 is it worth it for OEM to force them to push back on  
21 getting, like, one percent of the capability more  
22 versus letting them invest on R&D to come up with new

1 next generation of product, right? So that's also  
2 something to keep in mind.

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

16 So what I think these legacy requirements and  
17 retrofitting old equipment with new technology is going  
18 to do is kind of push out compliance for these newer  
19 sites coming in to maybe three further years down the  
20 line, you know, which is going to cause even more  
21 problems because there are more new resources coming  
22 online than there are legacy resources already out

1 there. So not just does it delay existing products or,  
2 you know, not just does it delay implementation for  
3 legacy, but it also delays existing or new products  
4 under development.

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

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

19 MR. SCHMIDT GRAU: Yep. When I speak today and  
20 also talk about it, the PRC-029, I'm solely talking  
21 about the 4 hertz per six seconds. We are largely  
22 very, very supportive of the standard, but that

1 specific requirement is depending on so many sub-  
2 manufacturers, redesign of the cells, different  
3 equipments, relays, that there is currently no product  
4 available with it. We can't retrofit any legacy  
5 turbines for it, and there is no product in design for  
6 future to meet plus/minus 4 hertz per six seconds.

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

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

19 MR. KOERBER: Generally, all our new product  
20 designs are aligned with 2800, so we're evaluating what  
21 it takes. As I've mentioned, several of us, including  
22 me, several times, the big concern is around the legacy

1 fleet, not new units. Generally, design power  
2 generation equipment, meeting grid codes is a key part  
3 of it. There's some specific technical requirements in  
4 PRC-029. Some of them were mentioned. Some of them  
5 were mentioned in our comments. The one we haven't  
6 talked a lot about here that we do see as requiring a  
7 bit of a realignment on our side would be multiple  
8 fault Ride-through, going from two events to four  
9 events in 029, in general aligned to 2800, evaluating  
10 what it would take to realign. The stronger concern  
11 and most of the comments are really around the legacy  
12 fleet, not new developments.

13 MR. DAHAL: I completely agree. Our newer  
14 products will comply with 2800, but we do not have --  
15 we haven't considered this 64-hertz-per-6-second  
16 criteria in any of our currently-being-designed  
17 product, so not the new one. We haven't considered  
18 that, and I don't think just a -- preliminary analysis  
19 doesn't allow us to be able to meet it just because of  
20 all the auxiliary motors that are in the turbines.  
21 And, you know, we are not going to get any assurance  
22 from our vendor that their motor would be able to Ride-

1 through those. So we don't -- we have no product.

2 MR. SHATTUCK: Thank you. Dinish?

3 MR. PATTABIRAMAN: So for products in development  
4 in the future, we'll be able to meet 2800. That's in  
5 our planned roadmap, but there are at least a few  
6 constraints with PRC-029, which limit us from meeting  
7 it. Some of these were mentioned before. You know,  
8 one of the examples is one-cycle filtering for  
9 instantaneous overvoltages, which we won't be able to  
10 meet. I heard somebody mention that, oh, greater than  
11 1.8 per unit, you know, there's not overvoltage going  
12 to occur on the grid side, but things could happen  
13 internal to the plant, which could trigger that kind of  
14 overvoltage. There could be a resonance condition.  
15 There could be a failure of one of the components that  
16 could cause a severe overvoltage. There are extensive  
17 studies done, called temporary overvoltage studies, to  
18 determine how much energy a surge arrester can handle  
19 and so on. So the various constraints would limit us  
20 from, you know, achieving this one-cycle filtering for  
21 instantaneous overvoltages, including inverter  
22 protection, inverter components, OX components within

1 the inverter.

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

16 Significant phase jumps. So essentially, the  
17 language states that if there is a fault event causing  
18 a significant phase jump, like a 90-degree phase jump,  
19 the plant is supposed to Ride-through. But that is  
20 something that we cannot really ensure, you know, the  
21 significant phase jump is going to instantaneously  
22 cause the current to jump significantly high and trip



1 the plant. So these are the differences -- the key  
2 differences between 2800 and PRC-029, which pose  
3 challenges. That's why I mentioned earlier and why the  
4 differences between 2800 and PRC-029 when 2800 has been  
5 discussed extensively, approved widely by a lot of  
6 people, and there's also test procedures coming in with  
7 2800.2.

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

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

1 can't figure it out.

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

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

20 So we need a mechanism to allow to use the  
21 adequate information, and we need ISOs/TSOs to be more  
22 upfront with the usability requirements for our models

1 and validation requirements for it. So that's an  
2 accountability we have to take on as an OEM, but again,  
3 that it's -- we can't afford any reliability issues  
4 either, yeah. So for sure, I speak for Vestas here, of  
5 course, not for all OEMs. Any concerns, if you heard  
6 anything else, please reach out, and we can definitely  
7 deep dive into that.

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

17 I have had my fair share with working with all of  
18 the ISOs where they would want accurate model, and they  
19 are absolutely refusing to work with a user-defined  
20 model. And then the question we get, so are you saying  
21 your generic model is inaccurate? That puts us in a  
22 very difficult position because we cannot say that we

1 have given an inaccurate model, which is not true, but  
2 it's what it is.

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

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

15 So when you guys come up with a new firmware or a  
16 new software upgrade, or, you know, different settings,  
17 if there is a modified change, which every utility  
18 should have in their interconnection requirements, you  
19 know, one of the modified changes, it's a new model.  
20 One of the modified changes is, you know, more than  
21 five percent in this setting. So if you have that  
22 change, the TO, or me as a transmission planner, I

1 cannot accept your model until I do a new study to  
2 determine if there is any new impact on the system by  
3 those changes, and that's the process that we have.  
4 It's a process that should work.

5 So you know, new models are working for any TO.  
6 The thing is that they have to be restarted if there is  
7 a modified change determined by the utility, by the TO,  
8 and they have for -- you know, due to -- I mean, in FAT  
9 002, every TO, every utility has to expel what the  
10 requirements are or what the -- what they call modified  
11 change to trigger the restudy.

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

14 MR. COOK: Yeah.

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

1 question.

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

4 MR. SHATTUCK: Yes. Thank you.

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

9 MR. DAHAL: Absolutely.

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

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

13 MR. DAHAL: Yes.

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

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

22 So based on Alex's very quantitative presentation,

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

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

18 MR. SHATTUCK: Thank you.

19 MR. AL-HADIDI: Thank you very much. Husam from  
20 Manitoba Hydro. So maybe I have few questions based  
21 off my involvement in the standard itself. I know I  
22 take these standard looking at low frequency 57 hertz

1 for almost five minutes. You guys okay with that, it's  
2 not an issue, so you go only 56.1 hertz per six second  
3 become an issue or how that really change, because  
4 really it's a fluxing issue. It's a time-related  
5 issue. So if you can understand five minutes, then  
6 what's the difficulties on that for a low frequency?  
7 Then I'll go about our frequency, which is normal  
8 auxiliaries even for today's surplus machine where,  
9 under load rejection, the frequency goes to 70, 80,  
10 whatever the case.

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

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



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

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

1 integrated operation for certain number, but doesn't  
2 prevent it from running. And voltage per hertz is  
3 already like exception criteria in the standard. So is  
4 it voltage per hertz? Is it what the limitation of the  
5 equipment --

6 MR. SCHMIDT GRAU: We are talking frequency  
7 plus/minus 4 hertz per six seconds --

8 MR. AL-HADIDI: Okay.

9 MR. SCHMIDT GRAU: -- that there is no standard  
10 to, what I at least know, that is designing any  
11 equipment or certifying to that.

12 MR. AL-HADIDI: Okay. So it does mean it's only  
13 that 57 is okay, and for other frequency up to 62  
14 hertz, that's what you guys guarantee, or is this  
15 really the -- where we are right now, we need to move  
16 to that direction?

17 MR. SCHMIDT GRAU: Ask if it -- we had to do R&D?

18 MR. AL-HADIDI: Yeah. Is it R&D?

19 MR. SCHMIDT GRAU: It's not R&D. It's about we  
20 are not able to source equipment that is designed or  
21 certified to that for the auxiliary systems.

22 MR. AL-HADIDI: Okay.

1 MR. SCHMIDT GRAU: Today.

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

5 MR. SCHMIDT GRAU: Yes.

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

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

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

22 MR. AL-HADIDI: Okay. What about ROCOF? Is 5

1 hertz per second something you -- is it something  
2 feasible to do, or it's -- where we are in that 5 hertz  
3 per second for legacy or for future design?

4 MR. SCHMIDT GRAU: Vesta's turbines, Type 3 and  
5 Type 4, all do 5 hertz per second, yeah. Vesta's Type  
6 3 and 4, it's public. You can go in. They comply with  
7 the NOGRR245 of August last year.

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

13 MR. PATTABIRAMAN: Our legacy equipment, there was  
14 no requirement for rate of change of frequency at the  
15 time these inverters were sold or commissioned. The  
16 standard at the time, I think, UL defined maybe 1 hertz  
17 per second as a requirement for some of these  
18 inverters. And so most of our legacy inverters are  
19 tested at 1 hertz per second and safe to operate in 1  
20 hertz per second without tripping. Like I said  
21 earlier, changing the software, it's not a simple  
22 parameter where you can go and update 1 hertz per 5

1 hertz per second. Software has to be changed  
2 extensively, and our legacy products don't support  
3 that. We would have to change hardware to even change  
4 software in some of the legacy inverters.

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

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

9 MR. AL-HADIDI: Sure.

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

1 sensors, a lot of things in turbines.

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

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

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

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

20 MR. PATTABIRAMAN: There are two ways. I think  
21 one is already the NERC recommendation, which is  
22 maximize settings to the extent possible, limit

1 instantaneous -- add additional filtering to  
2 instantaneous protection internally, and the other path  
3 is to kind of adopt 2800.

4 MR. AL-HADIDI: Okay. Thank you.

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

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

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

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

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

20 MR. SCHMIDT GRAU: I want to echo it.

21 MS. CASUSCELLI: All right. We'll do one last  
22 question here if that's okay, Todd. Thanks. There's a



1 question remotely here that asks if any of the  
2 panelists work with AEMO and provide source code for  
3 their models to the AEMO planners and operators and can  
4 speak to that.

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

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

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

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

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

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

16 So that model that gets submitted by the OEM to  
17 the customer might not be the same model that gets  
18 submitted by the customer to the TSO/RTOs as well, so  
19 that is also something to keep in mind. Everybody's  
20 talking about, oh, OEMs are hiding their control block,  
21 we need access to control blocks, we need access to --  
22 we need access to that parameter and that parameter,

1 while forgetting the fact that, you know, if you were  
2 to use the OEM/UDM model, you'll get a very accurate  
3 representation. And if you have to make changes, then  
4 you have to come to us. Then we will tell you what is  
5 possible and what is not with generic model.

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

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

1 Thomas down. Have you experienced that?

2 MR. SCHMIDT GRAU: Yes, pretty much all sites.

3 MR. KARPIEL: Yes.

4 MR. KOERBER: Sorry. Could you -- can you just  
5 restate the question, please?

6 MR. SHATTUCK: So the situation that was described  
7 where, you know, you've given a model out and then you  
8 get it back later from generator owner, utility, or  
9 whomever, and it's different, and you had no idea.

10 MR. KOERBER: I've not personally experienced  
11 this, but maybe I'm at a different part of the  
12 organization, so I can't comment on that.

13 MR. SHATTUCK: Okay. Thank you.

14 MR. KOERBER: I assume yes, but I can't confirm.

15 MR. SHATTUCK: Finish? You already answered.

16 MR. PATTABIRAMAN: Yeah, I already --

17 MR. SHATTUCK: Yeah.

18 MR. DAHAL: Yeah, absolutely. In fact, we have  
19 provided RECA models, and we have received REECC back  
20 for some reason.

21 (Laughter.)

22 MR. SHATTUCK: All right, good. I think we're

1 done then.

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

8 (Applause.)

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

17 (Break.)

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

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

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

9           Manish Patel, EPRI.

10          Andy Hoke, National Renewable Energy Lab.

11          MR. CHWIALKOWSKI: Todd Chwialkowski, EDF  
12 Renewables.

13          MR. LAUBY: Mark Lauby, NERC.

14          MR. GUGEL: A man who needs no introduction.

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

19          (Laughter.)

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

1 MR. GOGGIN: Michael Goggin with Grid Strategies.

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

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

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

16 MR. LAUBY: Models, no.

17 (Laughter.)

18 MR. LAUBY: One of the -- I think one of the  
19 challenges is it reminds me of when I used to work in,  
20 in Asia, and they'd come to me and say, well, how much  
21 coffee do you want, and I'd say, how much did you make.  
22 We're almost in that situation now where we're saying



1 to folks, well, you know, please give me this amount of  
2 frequency or voltage, and they say, well, how much do  
3 you need, and we can't answer the question, even 2800,  
4 of course, which is a global standard, right? It's  
5 kind of a -- I'll call it a global foundation, but we  
6 haven't done the hard work. And what I mean by "the  
7 hard work" is, you know, doing the system analysis to  
8 understand what are the frequency response that we  
9 need. How do we know that what we're putting in the  
10 standard is going to ensure that we have sufficient  
11 amount of Ride-through, be it voltage or frequency?

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

20 So I think that's one of the hard parts is having  
21 the data and the models and the simulations. We got to  
22 get beyond the inverter-based resource and what it can

1 do to getting to what do we need, and then how will --  
2 how will we drive the -- a standard to get there, so  
3 what's a good starting point? Well, you know, I'll  
4 leave it to the Drafting Team and the people -- and the  
5 folks here, but, you know, clearly we're -- it's kind  
6 of like a golf site, the old flat start. We're going  
7 to start someplace, and then over time, we'll find out  
8 as this evolves, if we need more or less.

9       There are places -- I talked to Jason -- not there  
10 yet -- 2800 would actually cause you problems, voltage  
11 collapse problems if you -- if everybody finally went  
12 2800. So you got to do this hard work to say, hey, in  
13 some places I'm going to have to have less than 2800,  
14 and that's okay, it's easy to do that, and some places  
15 you're going to need more depending on where you're at,  
16 but then that's okay, too. You can do more than the  
17 standard, and less, just make sure you have the  
18 technical reasons for doing that. So it's not easy,  
19 and you need good models and good simulation tools.

20       MR. GUGEL: Yeah. So to -- so to kind of build on  
21 that because now we -- I think we kind of see the  
22 issue, maybe we could talk about the magnitude of the

1 problem here. So from the rest of the panelists, from  
2 your perspective, you know, what percentage of the  
3 existing portfolios would be affected by the draft PRC-  
4 029 criteria, and how would that change? Would there  
5 be less or more affected if you changed that criteria  
6 to meet 2800?

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

17 So, you know, 20 to 50 percent of several hundred  
18 gigawatts is a hundred-plus gigawatts of existing  
19 resources that have major challenges with this, would  
20 either require extensive retrofits or complete  
21 retirement and replacement of the resources. And, you  
22 know, we've heard a lot about the wind, but, you know,

1     anecdotally, we've seen with solar and batteries, I  
2     think it's an issue of just, you know, these -- all  
3     these plants were designed before the standard was  
4     thought of.  And so it's very difficult with a few  
5     months' notice to go out and find out what the  
6     capability of the plant is and, you know, how perform  
7     -- just trying to meet this.

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

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

11 MR. CHWIALKOWSKI: I'll go next. EDF, again, EDF  
12 renewables, a developer, and I'll go down the path of  
13 we've had an opportunity already to do some of our  
14 analysis with ERCOT. Now, ERCOT jumped ahead of NERC,  
15 and they went forward with their Nodal Operating Guide  
16 245, and they're looking at, at this point, forcing us  
17 to maximize -- at least analyze the maximization of our  
18 sites within the ERCOT region.

19 So we've had a chance to work very closely with  
20 the OEMs and try to figure out where do we stand with  
21 our current fleet. And I have some numbers for you and  
22 I don't mind sharing them, but I'll also ask the other

1 developers in the room please share that information.

2 I know some of you have some numbers, and we aren't the  
3 biggest developer out there, but our numbers are also  
4 pretty significant. So for us, looking at the new PRC-  
5 029, similarly, as we looked at NOGRR245 and IEEE 2800,  
6 we're looking at almost 40 percent of our fleet being  
7 affected by this and affected in multiple ways, not  
8 just frequency alone, not just voltage alone. But when  
9 you look at our older fleet, our older turbines in the  
10 ground, it's both the voltage and the frequency Ride-  
11 through that's an issue.

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

1 supposed to do as a developer or as a generator to get  
2 that information to answer the regulator?

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

21 But I think what Mark said at the beginning, let's  
22 get something that -- what we can get from industry

1 right now without slowing down the deployment of these  
2 plants and without causing, you know, PEP companies to  
3 go out of business and get what we can now. And in the  
4 meantime, researchers like us will try to figure out  
5 what the grid is really going to need and have a better  
6 idea of that, and maybe we need to revise it and come  
7 back to this in the future. So get the low-hanging  
8 fruit now, get a good Ride-through standard now that  
9 everyone can be on board with, and then if we need to  
10 revise it in the future, we can revise it.

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

14 (Laughter.)

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



1 standard. It is voltage and frequency trip-setting  
2 standard.

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

17 So anyhow, we wrote lot of 2800 requirements  
18 thinking about future grid. A lot of folks were  
19 involved, 400-plus, and they all agreed to some of  
20 those requirements. As far as how many GOs or  
21 portfolio will be affected by either PRC-029 or IEEE  
22 2800, you heard OEMs. I think a couple of numbers

1 stuck to my head was one OEM said 40-gigawatt capacity.  
2 Another one said 50 to 60,000 units, right? Fifty to  
3 60,000 units. So that's just few examples.

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

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

1 necessarily meet that, but to come close to what's  
2 shown in PRC-029?

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

16 So all these are very different technologies, and  
17 limitations for one technology might not be the same  
18 limitation for another technology, but it seems like at  
19 the end of day, a lot of these things came down to a  
20 lot of auxiliary equipment that is designed on some  
21 other industry standards -- IEC NEMA curves, all that  
22 kind of stuff that is sourced by OEMs of wind turbine

1 generators, solar PV BES, and VSC HVDC to go along with  
2 their equipment. So it comes down to a lot of  
3 auxiliary equipments.

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

16 MR. GUGEL: Well, maybe I can take us in a little  
17 bit different direction then because there's a question  
18 that I've had. If we made a switch, it seems like the  
19 vast majority of inverters that are at least on the  
20 legacy equipment and may be specified for now, tend to  
21 be more grid following. If you made a switch to take  
22 those inverters to grid forming, would that maybe solve

1 some of the issues that we're talking about for voltage  
2 and frequency Ride-through?

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

5 (Laughter.)

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

22 MR. GUGEL: Good. That's a question that folks

1 have asked me in the past. And, you know, I didn't  
2 stay at a Holiday Inn Express recently, so I didn't  
3 have a good answer for it, but I thought maybe some of  
4 the smarter heads here might have a good one for that.

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

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

20 MR. PATEL: So I think repeating myself and  
21 repeating with everyone else on the previous panel, I  
22 think a lot of this limitations is not only the wind

1 turbine or the -- or the inverter. It's a lot of  
2 auxiliary equipment, right? Grid forming won't change  
3 in the auxiliary equipment. It remains same, so.

4 MR. GUGEL: Right. Okay.

5 (Cross talking.)

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

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

22 We rely on the source of truth, the OEM, to give

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

15 Now, if you have a homogeneous system and you have  
16 one OEM, one model type, that works out pretty well.  
17 You put two model types out there, it gets a little  
18 more difficult. Two OEMs each having one model makes  
19 it even more difficult. We have a site with three OEMs  
20 and multiple model types. It's easily a year to get a  
21 model set together to submit. That's the process that  
22 we go through, but again, to answer your question, on



1 the hardware side alone for the turbine, the OEM. I  
2 mean, if we can't get an answer from them in a  
3 reasonable time, that's where we stand.

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

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

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

17           You should define the need, and I think it's clear  
18   that the plus or minus 4 hertz per six seconds is not  
19   based on any real need, based on, you know, the charts  
20   we've seen this morning and the 10 NERC reports. You  
21   know, there's never been a frequency deviation that  
22   large, and, you know, just thinking about what would

1 happen. If the frequency is down at 56 hertz, every  
2 conventional generator would've tripped off, you know,  
3 or at 59 hertz, all the load would've tripped off  
4 around then, too. You know, what's the point? What  
5 are we trying to achieve here by making IBRs stick  
6 around while every -- the entire other power system --  
7 rest of the power system goes black?

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

21 And with IBRs that have fast frequency response,  
22 grid-forming capability, and other things, frequencies

1 are even more tightly controlled with lots of  
2 batteries, with, you know, controlled renewables. I  
3 think we're moving to a where frequency is even more  
4 tightly controlled than it is today. And so let's, you  
5 know, first establish that need and then work backwards  
6 from that, and then set the requirements based on that.  
7 Let's not go with this backwards route of, oh, we can,  
8 you know -- we think inverters can do this, so we're  
9 going to make them.

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

20 If you go back in history, we have had in Florida  
21 somewhat, fairly large, you know, frequency excursions  
22 that have occurred. And we're trying to protect not

1 just for some of the things that we've seen recently,  
2 but for events that could occur on the system that are  
3 much more drastic than that. We're trying to stay out  
4 of that.

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

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

14 MR. LAUBY: Yeah, Edison, and I saw that. No, I  
15 think you're right, Howard. I think that -- I don't  
16 see this as a discriminatory act. I know the Drafting  
17 Team is struggling with what -- with the tools they  
18 have and the experiences they have. I think the  
19 challenge has been that we're saying throw a ball, but  
20 we won't tell them how fast we're throwing it and how  
21 far it's got to go because we haven't done the studies.  
22 Back in the day when you were adding a generating

1 plant, you ran all sorts of different contingencies,  
2 and you made sure that you didn't impact your neighbor,  
3 that you had all the models right, and you knew how  
4 that thing was going to play within the system. It  
5 seems that we haven't done that in some -- in these  
6 cases, maybe because there's just so -- the number is  
7 so large and has overwhelmed the system.

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

15 MR. PATEL: So may I add something real quick? I  
16 think -- I think we have been focusing -- so we're in a  
17 football season, so let me give you an analogy. My  
18 team lost the football game over the weekend. I'm glad  
19 I'm here so I can forget about all that. But they were  
20 -- they're a pretty good defensive team, but they  
21 couldn't move the ball on offense. You can't win the  
22 game, right? So we are talking about Ride-through

1 capability, this frequency deviation for this time.

2 And there is -- a big other side of it is that, what  
3 does IBRs do, or any other resources do, when the  
4 frequency is abnormal for certain amount of time?

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

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

21 MR. COOK: No, keep going.

22 MR. GUGEL: Okay. You know, one of the -- and I'm

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

16 MR. HOKE: That's not in the script, but we can  
17 say a little bit about it. So right now, Manish and I  
18 and a whole bunch of other people in this room are  
19 writing IEEE 2800.2, which is the procedures to verify  
20 conformance IEEE 2800. And from a really high level,  
21 what that does is it takes an IBR unit, which is an  
22 individual turbine or an inverter, and do some tests,



1 whether that's in a lab or in a field or even in a HIL  
2 setup. And just doesn't try to make sure that it can  
3 do any certain thing, but just make sure that its  
4 behavior matches its model. And then you take that  
5 model or that IBR unit, which is now verified to match  
6 the behavior of the -- of the device itself, and you  
7 build a plant-level model, and you do a couple -- a few  
8 simulations, fairly simple simulations, really, on  
9 that, to make sure that it meets the behavior and --  
10 that you need for my IEEE 2800, for example, or from  
11 whatever other source requirements document you're  
12 looking at.

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

22 You would also see it in the testing phase 2

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

16 MR. GUGEL: Okay.

17 MR. LAUBY: One thought I had on this is, what  
18 we're getting to is, you know, inverters themselves  
19 have wonderful characteristics of being able to move  
20 very quickly. And so we need to be able then to ramp  
21 up our sampling or monitoring very quickly because they  
22 need sometimes to act at the speed of light to protect

1 themselves. So I think, you know, the -- I think that  
2 the sampling rates have to increase or monitoring rates  
3 need to increase so that then the remedial actions and  
4 mitigations can take place, and also, that that  
5 information can flow to other inverters in the area.  
6 I'm going off, this is the reason why, and, of course,  
7 then they can act accordingly, too.

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

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

7           MR. COOK: So there's question from the script  
8 that I'd like to have addressed right now, and it's  
9 Question Number 3. And it says, what are reasonable  
10 solutions to ensure legacy equipment can be compliant  
11 with the frequency criteria in Draft PRC-029 Attachment  
12 2?

13           MR. GOGGIN: Yeah, I can offer some thoughts  
14 there, and I think it's instructive to go back to Order  
15 901 from FERC. They pointed to the language that's in  
16 PRC-024 that has equipment limitation exemption  
17 process, and, you know, there are some things similar  
18 in the current draft of PRC-029 for the voltage-related  
19 requirements. I think that's what is needed for these  
20 existing resources.

21           You know, I think we heard on the last panel that  
22 there needs to be reasonable accommodation for, you

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

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

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

16           FERC was silent on frequency Ride-through  
17   requirements because we weren't talking about that in  
18   the comments that we were submitting. FERC was clear  
19   that they were okay with exemptions for resources that  
20   would have to replace their equipment, and, you know,  
21   FERC's logic is there's not a lot of these, they're  
22   going to be replacing their equipment anyway as

1 inverters age out, and, you know, we're repowering the  
2 wind fleet anyway, and so there's no reliability risk  
3 here, so we can have these exemptions.

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

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

16 MR. LAUBY: I would add to that, I think it's  
17 important that we understand -- we planning engineers  
18 understand what is the state of the network. What is  
19 the state of the generators in the sense that when I do  
20 my studies and I have an overfrequency, I know which  
21 ones are going to go out and which ones are going to  
22 hang on. I also want to understand the implications of

1 the ones that go out on the ones that did stay on, and  
2 do they create more of a frequency issue. So I think  
3 going through the process of -- you know, going through  
4 the attestations and understanding the state of the  
5 generators that are on the network, plus, of course,  
6 those that we're adding, that when we do our system  
7 studies, we'll have a much clearer picture of really  
8 where we stand.

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

18 Bueller?

19 (Laughter.)

20 MR. YEUNG: Yeah, I'm on. I had to get clearance  
21 from Jamie first before I asked this question because  
22 I'm a -- I'm a moderator for tomorrow. But today my



1 question is solely from the ISO/RTO perspective. My  
2 name is Charles Young with Southwest Power Pool, and  
3 I'm not sure if there's many other RTOs in the room  
4 here today, so I thought -- I want to raise this issue.

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

1 high.

2 So how does an ISO do that? How do -- how do we  
3 get resiliency without getting into PRC-024 operations?

4 The only tools we have as operators is operator  
5 intervention, and that can be a range of things, right?

6 We can reconfigure the grid, we can put resources on  
7 resources online, and, as an RTO, it could be out of  
8 merit, more than likely out of merit, or we can do  
9 curtailments of those assets we believe are at risk.

10 So that's our choice. I'm not hearing a lot today  
11 about the operator's tools and how these benefit the  
12 operator.

13 MR. LAUBY: I left it on this time just in case.  
14 I think the way to get to it, of course, as a -- I'm  
15 thinking operational planning drop, right? You got to  
16 -- like you say, we got to model this stuff. We got to  
17 know -- we don't want to be running the system in  
18 unstudied states, so we need the information on what  
19 the expectations are. How are they going to behave?  
20 Every one of these plants, how are they going to be  
21 behave under certain system conditions so that when we  
22 study them ahead of time, you can pre-position yourself

1 rather than kind of go, oh, surprise, guess what,  
2 another thing happened and another thing happened.

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

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

1 during certain events. You're kind of learning on the  
2 fly.

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

18 MR. CHWIALKOWSKI: I'll add one thing to that,  
19 also, just to answer your question. I think to help  
20 you out, we do need better modeling, no question, but  
21 better data also is important. I mean, that's two of  
22 the things that I think are very important that we can

1 look at retrospectively versus prospectively, where we  
2 have the technical capability and it's also  
3 commercially reasonable. That's where you establish  
4 that balance, right, of going down that path. And I'm  
5 going to quote Alex from earlier this morning where he  
6 mentioned, you know, what is it that we should focus on  
7 moving forward? I think a couple of solutions are  
8 right there, right in front of us -- better data  
9 collection and then better modeling -- and for that, we  
10 need our source of truth, the OEMs. So, Alex, you're  
11 there.

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

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

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

11 MR. GUGEL: I'll take the first step on that.  
12 Nice for the compliance guy to jump in here, I know,  
13 and you're all fading. You know, I really would look  
14 to the technical experts to develop some reliability  
15 guidelines around that. You can kind of think of what  
16 we -- what we set up at NERC for reliability standards  
17 as being the guardrails, if you will, the extremes.  
18 But I think once you operate within that, then really  
19 you're looking toward your technical experts to decide  
20 what should be a best practice. And I'm going to use  
21 air quotes there because everybody's hates to do that  
22 because they're public utility commissions, hold to

1    them the different things.  But, you know, when you're  
2    within that, there's probably better ways to operate  
3    and less better ways to operate.  I don't think, at  
4    least from our perspective, we wouldn't define that in  
5    a reliability standard, but instead, that would be more  
6    operating practices.  Any other thoughts from the --  
7    from the panel here on that?

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

22           MR. SCHMIDT GRAU:  It makes perfect sense because

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

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

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

21 MR. SCHMIDT GRAU: Yeah.

22 MR. GUGEL: As they're popping in and out, they're



1 actually reacting to each other on that too, which --

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

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

7 MR. KARPIEL: (Off mic comment.)

8 MR. COOK: Okay.

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

11 (Laughter.)

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

21 Like for example, IEEE 2800 has an MFRT  
22 requirement, and it starts off with a paragraph, and

1 the first bullet under that paragraph says that the IBR  
2 shall not be required to withstand more than four  
3 consecutive voltage dips. Okay. That first bullet was  
4 picked up in PRC-029. Now, IEEE 2800 then goes on to  
5 say in the second and third and fourth bullets that if  
6 the voltage dip is less than 50 percent, then it only  
7 needs to withstand two consecutive voltage dips and not  
8 four. So those subsequent bullets were eliminated from  
9 PRC-029, and that kind of raises a question in my mind  
10 as to whether this is really intentional or accidental.

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

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

1 12:00 position can be -- an offshore wind turbine can  
2 be as tall as the Empire State Building. So IEEE 2800  
3 said, if you have mechanical resonances during MFRT  
4 events, then the wind turbine is allowed to trip to  
5 protect itself from those resonances. That part is not  
6 in PRC-029. Another example IEEE 2800 says V over F,  
7 for -- right? For V over F, it said -- it referenced  
8 certain equipment standards for auxiliaries and said if  
9 you go outside the envelope of V over F or F over V  
10 capabilities as specified in those standards for those  
11 auxiliary equipment, then you're allowed to modulate  
12 reactive power so as to adjust voltage and try to stay  
13 within those limits so that you don't trip. That  
14 requirement was f eliminated from PRC-029.

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

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

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

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

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

12 (Laughter.)

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

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

11 MR. VENKITANARAYANAN: Thank you.

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

1 the OEMs who are sharing their insight.

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

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

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

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

6 MR. BENNETT: Okay.

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

11 MR. GOGGIN: I'm not going to get into the  
12 technical details. I would note part of the reason why  
13 I have mentioned the need to have the standard apply  
14 prospectively from the signing of the interconnection  
15 agreement and not being placed in service as it is in  
16 the current draft is because of the long lead time for  
17 offshore wind, but also, you know, other land-based  
18 wind, you know, and solar and batteries also can have  
19 long lead times between, you know, when they sign the  
20 interconnection agreement and -- I'm sorry -- when  
21 they, you know, start developing the project and, you  
22 know, buy equipment and develop settings and things

1 like. And so, you know, having the requirements take  
2 effect for plants in service as is in the current draft  
3 would not work for these longer lead assets. And so  
4 that's -- you know, that's necessary to, you know, set  
5 the requirements and have them take effect based on  
6 resources -- signing the interconnection agreement  
7 after the date, you know, the implementation of the  
8 standard.

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

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



1 would be more of a network connection.

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

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

10 (Laughter.)

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

1 is out there on the system and what is going to be  
2 projected out there in the future would be very much  
3 welcomed.

4 MR. GOGGIN: I would just chime in that this is  
5 all the more reason to not do retroactive standards.  
6 It's extremely challenging to make sure that those  
7 standards work for everything that's out there,  
8 including the stuff that was built decades ago by  
9 somebody that no longer exist, and prospectively to use  
10 2800 because it's what the industry is designing  
11 towards, and so that process has already played out.  
12 You know, Order 901, we're having to do this very  
13 quickly and that approach of not retroactive and IEEE  
14 2800 prospectively is the safest way to avoid causing  
15 major unintended problems.

16 MR. GUGEL: Yeah. So I understand the concern,  
17 but we have many standards that are retroactive  
18 standards when they go into place. So I understand  
19 that we need to -- we need to have a concept and a --  
20 and a -- and a -- and a -- and a context of how this  
21 all fits in, but just because something is a legacy  
22 piece of equipment doesn't mean it needs to have

1 reliability issues and reliability constraints placed  
2 around it as it operates on the system because it can  
3 affect reliability just as importantly as things that  
4 are placed in the future.

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

21 MR. PATEL: May I -- may I say a few things? I  
22 think I agree in general that legacy equipment cannot

1 be detrimental to the reliability of the system, right,  
2 but I think we also need to look at a little bit bigger  
3 picture. I wanted to mention this when Alex was  
4 presenting earlier today, is that all the disturbance  
5 reports that have come out in last seven, eight years,  
6 those were because of something like momentary  
7 cessation or incorrect measurement of frequency, things  
8 like that, a spontaneous reaction of controls to system  
9 disturbance.

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

18 MR. GUGEL: I think potentially that's the case,  
19 yes. The only caveat that I would provide to that is,  
20 we continue in every one of these disturbances to see  
21 more things that come up, and I think being reactive  
22 for each one of these is not really a long-term

1 solution for reliability. I think, instead, if you set  
2 the parameters and then -- I hate to use the word  
3 "force," but have generator owner, operators, OEMs,  
4 others go out and validate that they can perform within  
5 those parameters, then you don't get into the situation  
6 where you fix one problem, and then a year later, you  
7 have another issue that occurs on the system that is  
8 somewhat related, but not exactly the same as what that  
9 previous one was. I think that's the concern that, at  
10 least we've seen from NERC, is that yeah, we go out and  
11 fix things as they happen, but you can't just continue  
12 to be reactive. We need to at least draw a line in the  
13 sand and say, these are the performance parameters that  
14 need to be met.

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

1 So I agree with you a hundred percent, Howard.

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

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

17 MR. BENNETT: That's kind of what I was thinking,  
18 also, on this is maybe this is a good spot to break for  
19 today. I will let everybody know that we have  
20 collected many questions online. And today, I think  
21 we're going to run out of time to do the Slido polling  
22 and kind of go through that exercise, but tomorrow

1 there'll be an opportunity for that, and I think we're  
2 going to circle back to some of our online themes  
3 tomorrow once we have -- can maybe discuss that a  
4 little bit more internally. So I think with that, how  
5 about we give everybody a round of applause for this  
6 great panel.

7 (Applause.)

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

16 MS. KELLY: I do.

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

19 MS. KELLY: (Off mic comment.)

20 (Laughter.)

21 MS. KELLY: I just want to thank everybody who  
22 came today, both virtually and in person, and I want to

1    thank the Standards Committee members who are doing all  
2    of this work on top of their day jobs.  Very much  
3    appreciate that.  And I want to thank the Drafting Team  
4    because I know they've spent countless hours working on  
5    these issues, and I appreciate those who came today to  
6    explain the decisions they made and why they made them.  
7    We owe them our thanks.

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

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



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

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

17 Third, I loved Alex Shattuck's Venn diagram. I  
18 love Venn diagrams from sixth grade. It's one of the  
19 few mathematical concepts I was able to absorb. How  
20 much future Ride-through performance should we demand  
21 from our resource base, and how much are we going to  
22 have to pay to get that? We cannot use today's

1 regional grids and generation mixes to decide how much  
2 is enough because, again, as David pointed out this  
3 morning, we're anticipating a very quick ramp-up in  
4 IBR-based resources. And so the ground is shifting  
5 under our feet, and the requirements are going to have  
6 to shift as well.

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

17 So I'm going to be thinking about all this  
18 tonight, and I'm sure you will as well. Hopefully  
19 we'll have another productive day tomorrow. We'll be  
20 back 9:00 tomorrow, and I will note that breakfast and  
21 lunch are up one level -- this is my most important  
22 duty -- up one level in River Birch A, and there will

1 be signage to direct you. Breakfast will be available  
2 at 8:00. I hope to see everybody there. Thank you  
3 very much for your time and attention and deep thinking  
4 today.

5 (Applause.)

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

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

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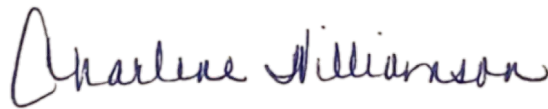
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