NERC

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Aggregated Report on NERC Level 2 Recommendation to Industry:

Findings from Inverter-Based Resource Model Quality Deficiencies Alert
April 1, 2025

Overview
NERC issued a Level 2 Recommendation to Industry for Inverter-Based Resource Model Quality Deficiencies in June 2024, specifically requesting responses from Generator Owners (GO), Transmission Planners (TP), and Planning Coordinators (PC). The alert was posted publicly on the NERC website and required GOs who own bulk power system (BPS)-connected inverter-based resources (IBR) to provide a Data Submission Worksheet, (hereafter: "Worksheet"). The alert had an initial Worksheet submission deadline of September 2, 2024, and due to a low response rate, NERC extended the deadline to November 1, 2024. This resulted in NERC receiving sufficient responses to perform an analysis.

Based on the findings from this alert and the previous alert on IBR performance, a Level 3 alert with Essential Actions is needed to address the deficiencies identified in this Level 2 Alert.

Summary
NERC analyzed 10 large-scale disturbances on the BPS that involved the widespread and unexpected reduction in output of IBRs since 2016. These 10 disturbances totaled nearly 15,000 MW of unexpected IBR-output reduction, with approximately 10,000 MW of reduction occurring from disturbances between 2020 and 2024. The increase of IBR-related events coincides with an increase in IBR penetration across the BPS. Contributing causes to these events are poor modeling and poor study practices to assess the performance of these resources.

Performing dynamic simulations of the BPS enables TPs, in cooperation with GOs, to mitigate reliability risks before they occur. Accurate dynamic models of resources are critical to this analysis and to BPS reliability. Several of NERC's published disturbance reports included analyses of the models for the affected facilities, which revealed systemic dynamic model inaccuracies. These analyses also revealed that the models provided for conducting generator interconnection studies, or other system studies, failed to accurately reflect the dynamic performance of the plants. Accurate modeling of IBR facilities is critical in performing system studies to assess the reliable operation of the BPS.

The Inverter-Based Resource Model Quality Deficiencies Alert was distributed to all registered GOs of IBRs as modeling deficiencies, best practices, and recommendations are applicable across all IBR technologies. NERC encourages owners and operators of non-BES and BPS-connected IBR to also review the alert.

The significantly higher complexity and software-based nature of IBR modeling, when compared to synchronous machine modeling, necessitates an improvement in the fundamental principles of dynamic modeling to accurately capture the performance of IBR plants. This alert was also distributed to TPs and

PCs to provide recommendations that can be implemented to strengthen current modeling practices. TPs and PCs were required to answer a set of questions in the alert system; however, only GOs of IBR were required to complete the Worksheet.

The alert contained 8 recommendations, briefly listed below for background. For more details, refer to the full alert.[1]

Recommendation 1: All models should be detailed and accurate representations of expected or as-built facilities across all expected operational conditions. Changes to any model parameters, including plant controller parameters that change the performance of the IBR plant, should be studied to ensure BPS reliability before implementation.

Recommendation 2: Industry-approved standard library positive sequence phasor domain (PSPD) models are sufficient for use in Interconnection-wide base-case creation.

Recommendation 3: Equipment-specific models should be used for detailed reliability studies (e.g., during generation interconnection studies and local reliability studies). These equipment-specific models should be considered acceptable by a TP or PC if specific usability requirements are met.

Recommendation 4: Establish clear, consistent, sufficiently detailed, and comprehensive modeling requirements that include standard library, PSPD, and Electromagnetic Transient (EMT) models and are aligned with the recommendations in this alert and with the FERC Large Generator Interconnection Procedures (LGIP) and Small Generator Interconnection Procedures (SGIP). The requirements must include model quality checks and be updated as necessary (e.g., after an event where model quality is noted as an issue.)

Recommendation 5: TPs and PCs should require the following for each generator currently connected to the BPS to ensure that sufficient models and supporting documentation are provided. TPs or PCs should provide models and model updates to the Reliability Coordinator (RC), Transmission Operator (TOP), Balancing Authority (BA), and any affected stakeholders. For generating resources seeking interconnection to the BPS, model submission requirements should align with the FERC LGIP and SGIP.

Recommendation 6: Coordinate with inverter manufacturers, plant controller manufacturers, TPs, and PCs to meet all modeling requirements established by the TP and PC and provide adequate proof of conformance to the requirements

Recommendation 7: Maintain an accurate and representative model throughout the lifecycle of the project.

Recommendation 8: All applicable recommendations in the alert should be implemented so an updated set (e.g., standard library, equipment specific PSPD, and EMT) of dynamic models is included in the next applicable TP and PC annual model updates.

[1] https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC%20Alert%20Level%202%20-%20Inverter-Based%20Resource%20Model%20Quality%20Deficiencies.pdf

Key Findings

Like the previous Level 2 alert, feedback from industry (GOs, consultants, Original Equipment Manufacturers (OEMs), etc.) indicated that GOs do not keep the requested data and information readily available and up-to-date and are reliant on OEM and consultant support. Further, multiple major GOs expressed significant time commitments and difficulties in obtaining fundamental site information, such as basic plant controller settings.

To date, key findings include:

1. Many GOs indicated that they did not have the requested data readily available. This hampers future NERC event analyses and raises questions on the quality of the data submitted by GOs for study in the planning processes. This supports the findings from the previous Level 2 Alert: Inverter-Based Resource Performance Issues[2] and is indicative of a lack of knowledge of how IBR plants operate on the BPS and a failure to improve data acquisition and management processes.
2. The systemic deficiencies observed in this alert analysis indicate that the interconnection process requirements are insufficient. Enhancing requirements and study procedures, to be recommended in an upcoming level 3 alert,[3] could significantly mitigate these deficiencies.
3. Approximately two-thirds (66%) of the protection settings used by the respondent GOs are not set to provide the maximum capability of the inverters. This creates a significant artificial limitation of overall ride-through capability of BPS-connected solar photovoltaic (PV) facilities.
4. Approximately 20% of the facilities use a “triangle” (0.95 power factor (PF) limit) facility capability; therefore, a significant amount of underused reactive capability exists on the BPS.
5. Inconsistency in dynamic model data has been observed across different sources – GOs reported as-left settings, reported modeling data, and submitted dynamic model data files (e.g., .dyd and .dyr files), and dynamic model data from interconnection-wide cases. TPs and PCs can address the inconsistency by enhancing model requirements and quality-check processes for existing and new models.[4]

[2] https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/NERC%20Alert%20R-2023-03-14-01%20Level%202%20-%20Inverter-Based%20Resource%20Performance%20Issues.pdf

[3] It should be noted that the level 3 Alert contains only voluntary essential actions, and the mitigation of risk will be left up to individual stakeholders. The gaps observed in this Alert could be mitigated more efficiently and on a mandatory basis through common sense updates to the FERC *pro forma* Interconnection Agreements.

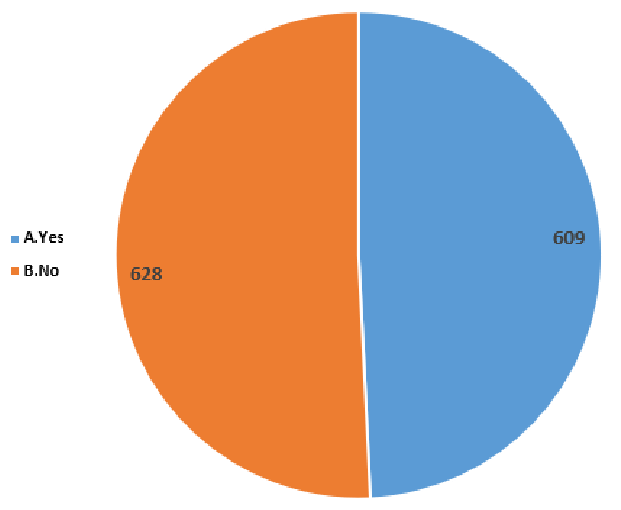
[4] This is planned to be included in an upcoming Level 3 Alert on required actions to mitigate against inconsistent dynamic representation of as-left, expected, or as-built facilities.

Summary of Results

The alert contained 16 questions, of which 1 was intended for GOs, with the remaining 15 targeting TPs and PCs. The following graphs and tables show a breakdown of the responses to select alert questions.

GO-1: Do you own any BPS-connected IBR generating facilities?

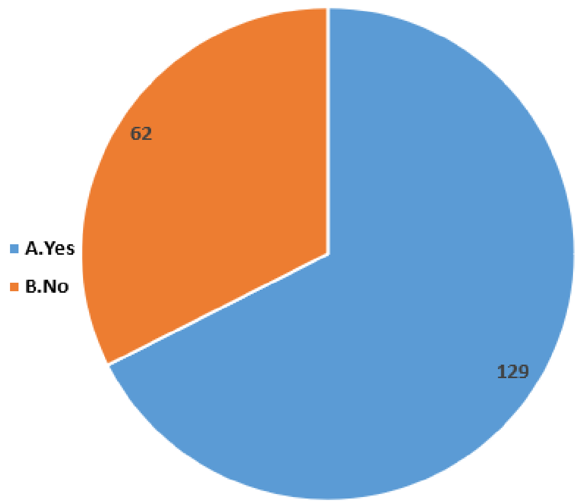
Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	609	49%	97	19	64	87	177	165
B.No	628	51%	49	104	142	108	81	144
Total	1237	100%	146	123	206	195	258	309



Approximately half of the responding GOs indicated that they owned BPS-connected IBR generating facilities – entities that submitted a "Yes" response were required to fill out a Worksheet that included data submissions for inverter and facility protection settings, reactive power capabilities, and facility level control methods.

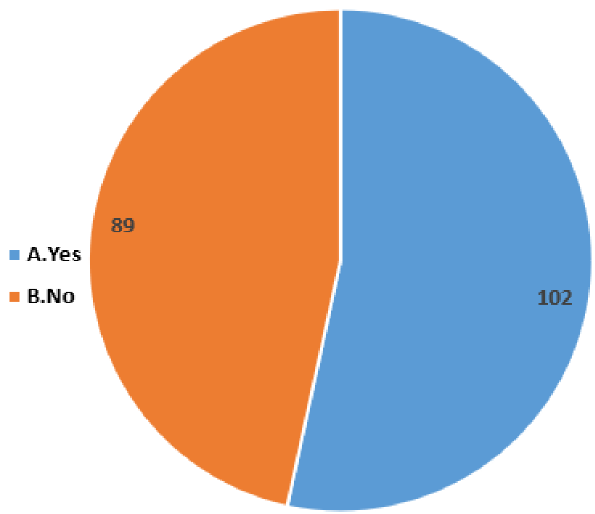
TP-PC1: Does your organization have publicly available model submission requirements?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	129	68%	27	15	10	27	15	35
B.No	62	32%	12	4	4	13	10	19
Total	191	100%	39	19	14	40	25	54



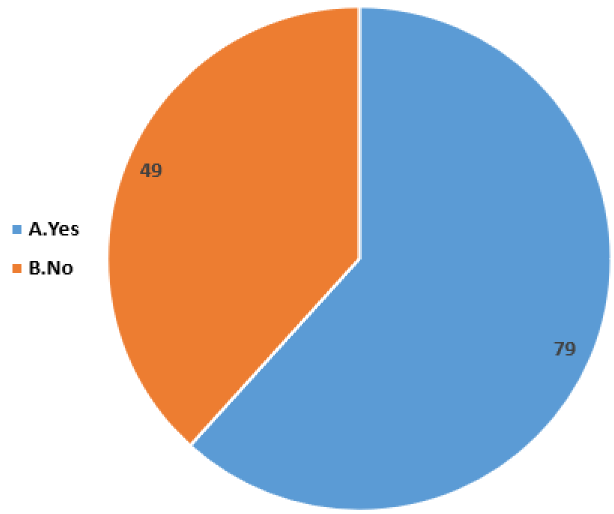
TP-PC2: Does your organization have publicly available model quality requirements?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	102	53%	23	14	9	23	14	19
B.No	89	47%	16	5	5	17	11	35
Total	191	100%	39	19	14	40	25	54



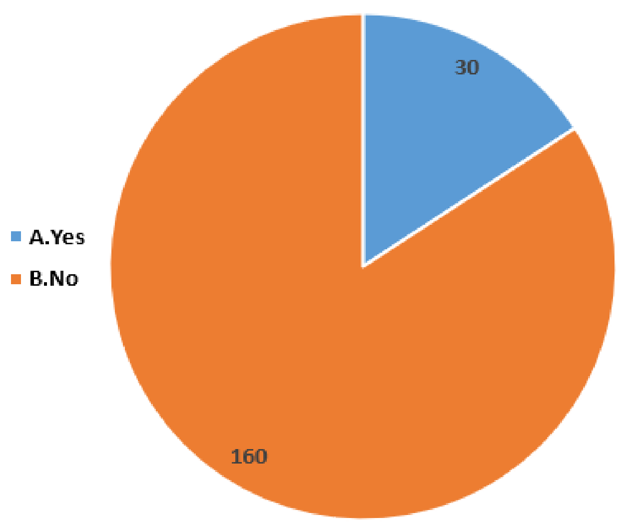
TP-PC3: If Yes to Question 1: Do you believe that your organization's modeling requirements align with NERC's Dynamic Modeling Recommendations?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	79	62%	10	10	3	19	14	23
B.No	49	38%	16	5	7	7	1	13
Total	128	100%	26	15	10	26	15	36



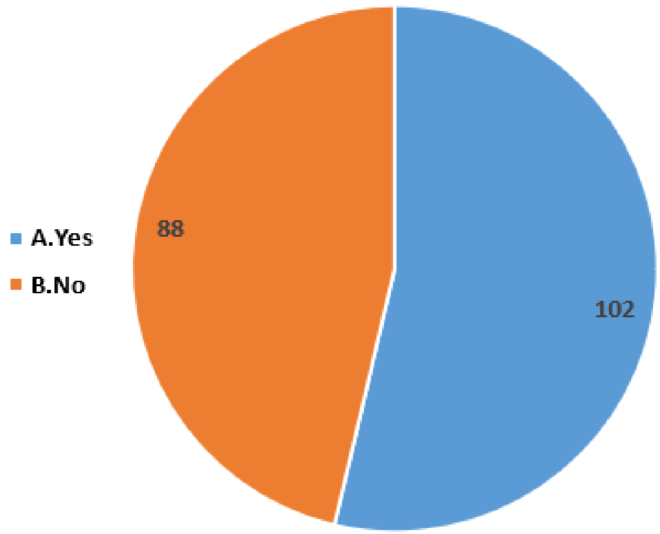
TP-PC5: Does your organization require the submission of equipment-specific, user-written positive sequence phasor domain (PSPD) generator models for interconnection studies?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	30	16%	7	0	1	11	4	7
B.No	160	84%	32	19	13	29	20	47
Total	190	100%	39	19	14	40	24	54



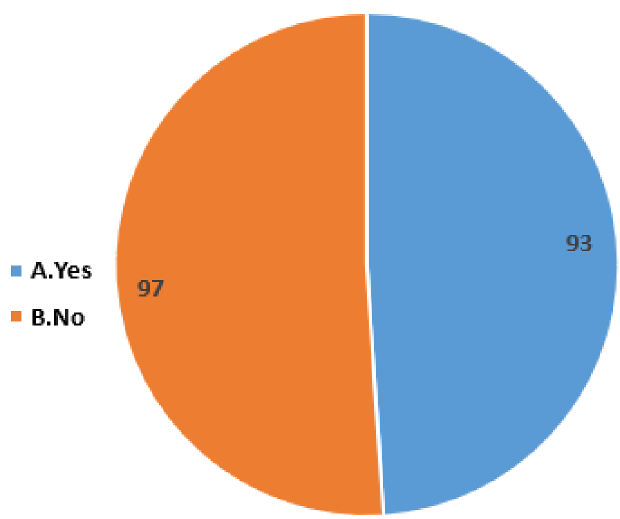
TP-PC6: Does your organization allow the submission of equipment-specific, user-written PSPD generator models for interconnection studies?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	102	54%	21	8	6	27	20	20
B.No	88	46%	18	11	8	13	4	34
Total	190	100%	39	19	14	40	24	54



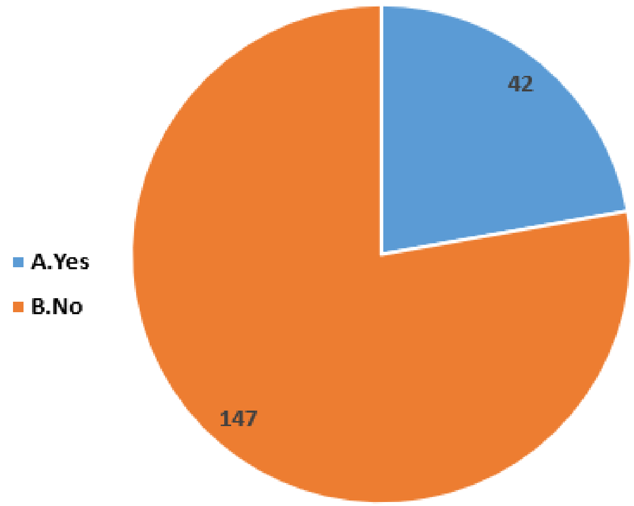
TP-PC7: Does your organization require the submission of equipment- and site-specific electromagnetic transient (EMT) generator models during the interconnection process?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	93	49%	18	9	10	21	15	20
B.No	97	51%	21	10	4	19	9	34
Total	190	100%	39	19	14	40	24	54



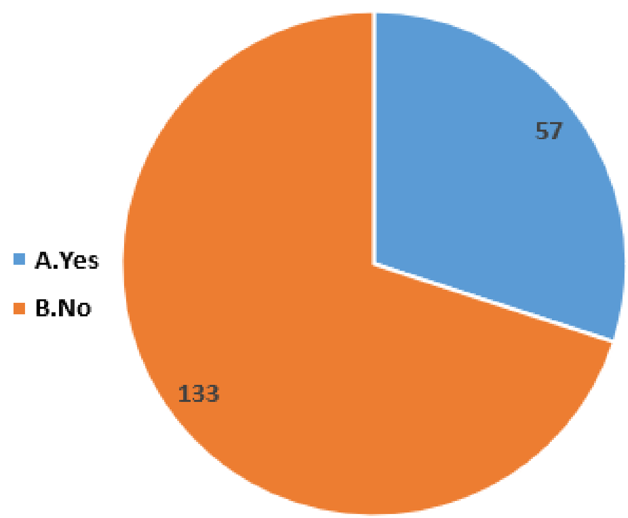
TP-PC8: Does your organization perform EMT model verifications to determine if the model meets published requirements?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	42	22%	2	10	1	6	11	12
B.No	147	78%	37	9	12	34	13	42
Total	189	100%	39	19	13	40	24	54



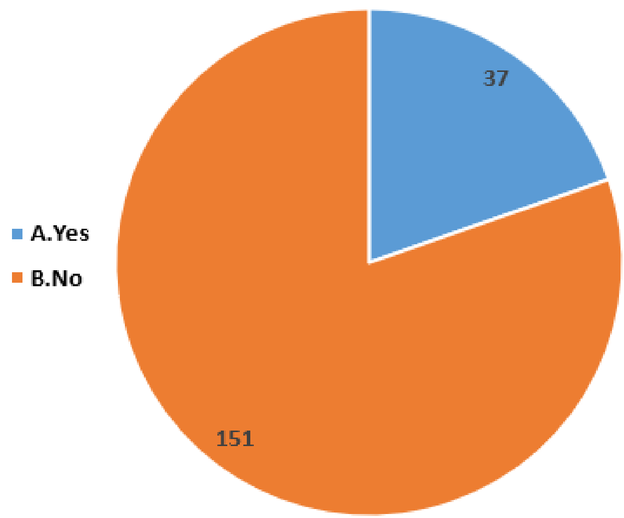
TP-PC9: Does your organization integrate EMT models into studies performed for your organization's generator interconnection procedures?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	57	30%	4	14	1	10	14	14
B.No	133	70%	35	5	13	30	10	40
Total	190	100%	39	19	14	40	24	54



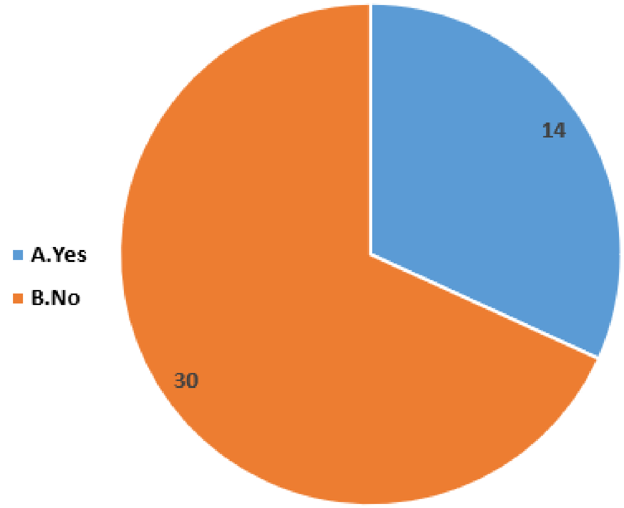
TP-PC10: Does your organization require generator model benchmarking reports that contain comparisons between all model types and actual equipment?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	37	20%	4	0	2	9	8	14
B.No	151	80%	35	19	12	31	15	39
Total	188	100%	39	19	14	40	23	53



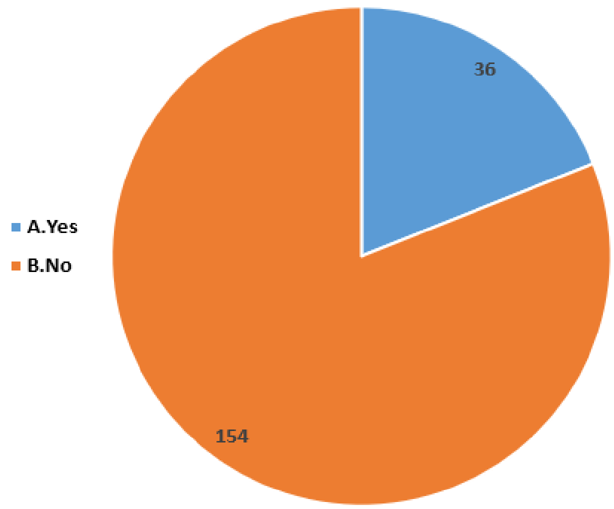
TP-PC11: If Yes to Question 10: Does your organization have quantitative metrics to determine model accuracy?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	14	32%	1	3	0	4	2	4
B.No	30	68%	4	0	3	5	7	11
Total	44	100%	5	3	3	9	9	15



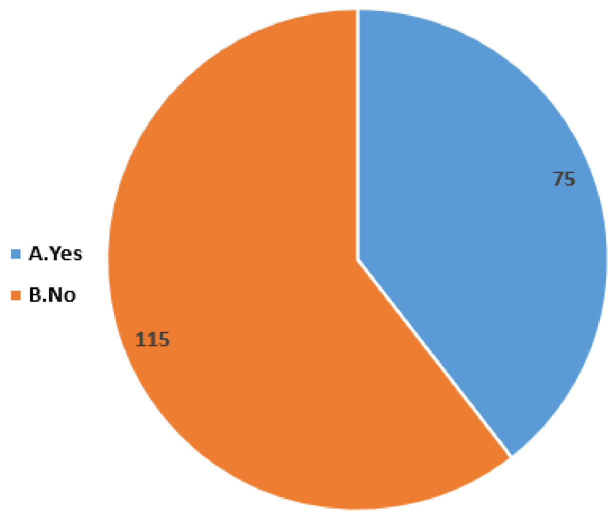
TP-PC13: Does your organization have the tools and personnel to effectively perform EMT analysis?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	36	19%	3	1	2	8	12	10
B.No	154	81%	36	18	12	32	12	44
Total	190	100%	39	19	14	40	24	54



TP-PC14: Does your organization have the tools and personnel to effectively perform analysis with equipment-specific, user-written models?

Answer	Total	Pct	MRO	NPCC	RF	SERC	TRE	WECC
A.Yes	75	39%	19	4	4	15	17	16
B.No	115	61%	20	15	10	25	7	38
Total	190	100%	39	19	14	40	24	54



Approaching the original September 2, 2024, response date, NERC staff observed low data submission numbers and alert participation. Additionally, multiple requests for a deadline extension were received from GO entities. This was likely driven by the level of detail requested by NERC to assess the extent of condition of the IBR fleet and the reliance on OEMs and third parties to obtain facility data. The Worksheet requested a significant amount of information, but the data was selected based on NERC's reasonable expectation that the information would be readily available. The Worksheet requested information including:

- Protection settings installed in the inverters and on other applicable equipment
- Inverter and facility reactive power capabilities
- Installed control modes and response settings
- Transient stability model parameters

NERC conducted conversations with GOs throughout the alert process to seek feedback on the alert administration and the Worksheet submission process. The following feedback was received, which closely mirrors the feedback received through the previous Level 2 alert on IBR performance issues:

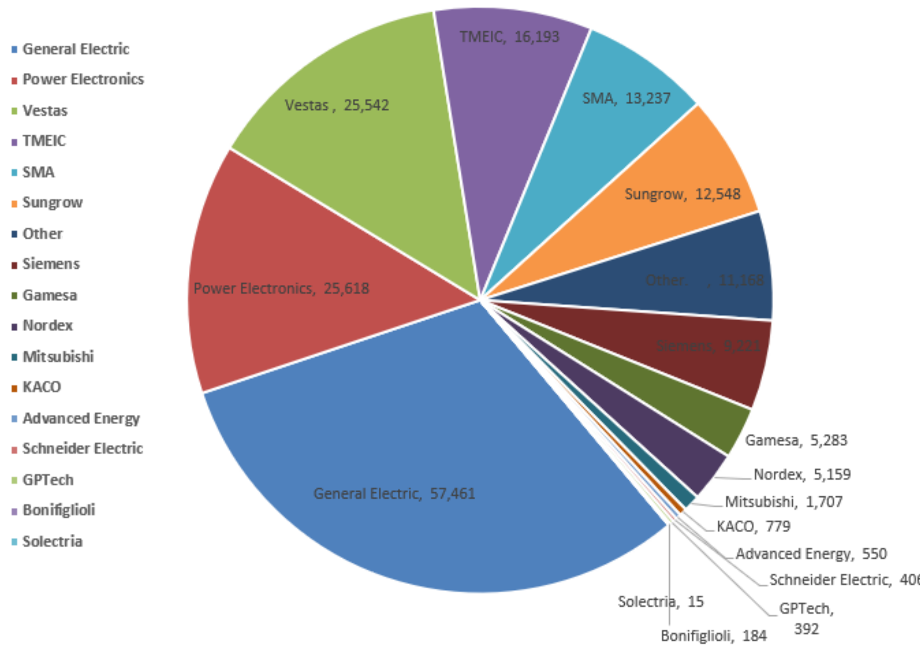
- GOs had difficulty populating the Worksheet without significant assistance from equipment manufacturers or third-party consultants. Multiple GOs relied entirely on equipment manufacturers and/or third-party consultants to populate the Worksheet.
- GOs communicated considerable time commitments to complete the Worksheet, which is indicative that the requested fundamental information is not retained or accessible.

The initial low Worksheet submission rate illustrates that most GOs did not have the data requested readily available, which has the potential to hinder event analysis efforts following BPS disturbances.

Manufacturer and MW Information

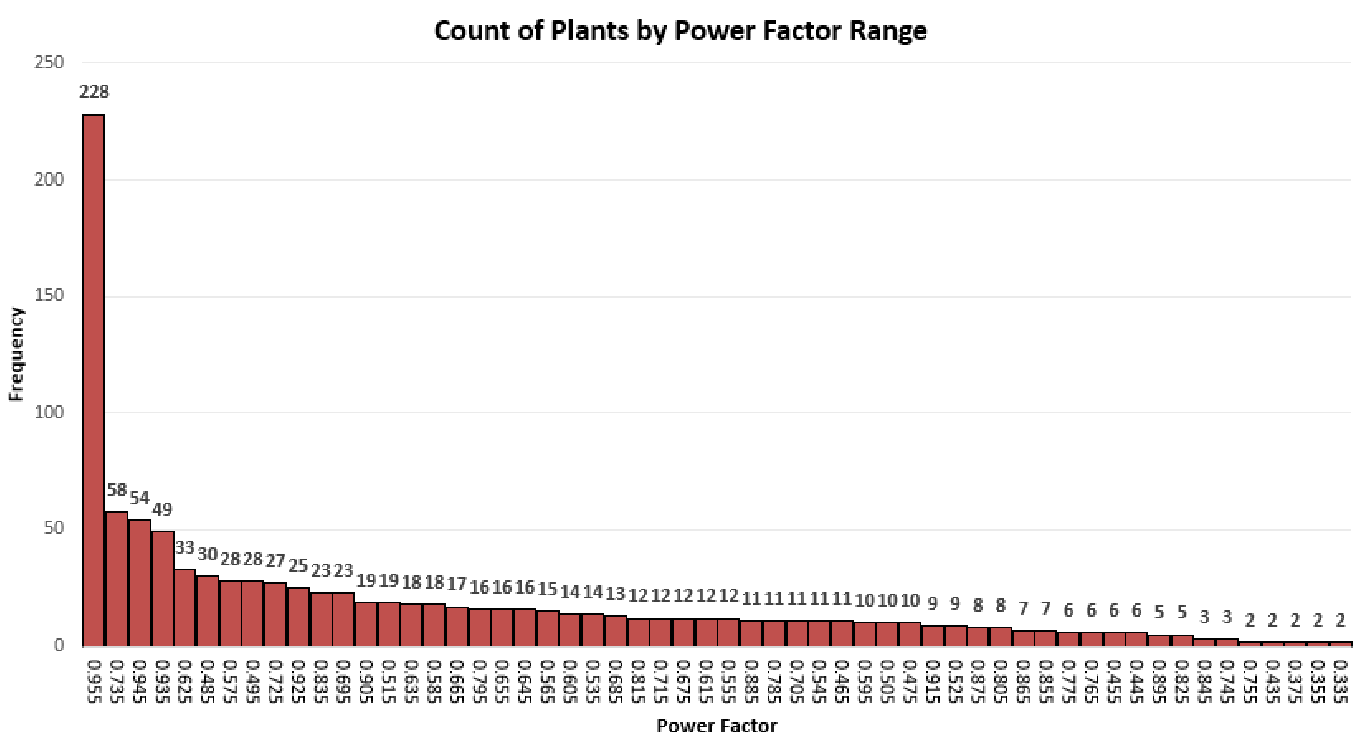
The list of manufacturers by MW is shown below, along with a percentage chart to share the relative scale each of the various manufacturers of IBRs in the fleet. The top five OEMs reflect 83.1 percent of the fleet.

Manufacturer Name	MW	%
General Electric	57,461	31.0%
Power Electronics	25,618	13.8%
Vestas	25,542	13.8%
TMEIC	16,193	8.7%
SMA	13,237	7.1%
Sungrow	12,548	6.8%
Other	11,168	6.0%
Siemens	9,221	5.0%
Gamesa	5,283	2.8%
Nordex	5,159	2.8%
Mitsubishi	1,707	0.9%
KACO	779	0.4%
Advanced Energy	550	0.3%
Schneider Electric	406	0.2%
GPTech	392	0.2%
Bonifiglioli	184	0.1%
Solectria	15	0.0%
Total	185,461	100%



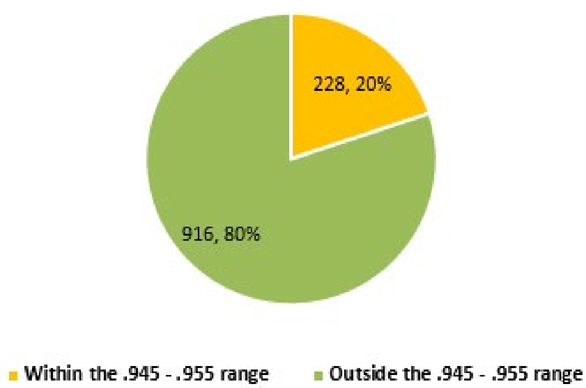
Facility Reactive Power Capability

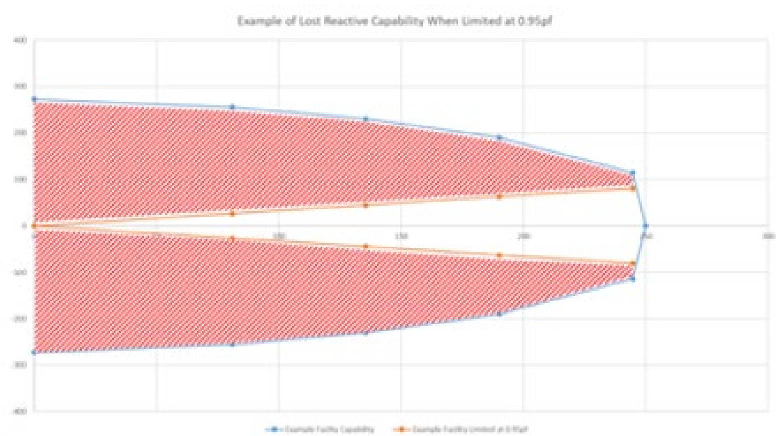
The Worksheet requested data on the reactive capability of the asset at nominal voltage levels. A facility capability curve was produced for each plant, and a power factor (PF) was calculated for each data point provided. A histogram showing the distribution of the average PF at each facility is below.



NERC calculated an average PF at each facility to categorize those with triangle-shaped facility capabilities (limited to a 0.95 PF at all active power levels) instead of those based on the maximum capabilities of the equipment. The breakdown of each category is shown in the pie chart below with 20% of the facilities reporting a triangle-capability curve.

This percentage of triangle-facility capability indicates that limits on reactive capability are artificially low. Reactive power capability is essential for maintaining the voltage of the BPS, and most modern solar PV inverters have reactive capabilities exceeding 0.95 PF at their terminals. Artificially limiting the reactive capability at solar PV facilities, or any facility, can significantly reduce the overall reactive capability of the BPS. The figure below shows an example PV facility with a non-triangle-shaped capability with an overlaid 0.95 PF curve. The red-shaded area shows the lost reactive capability when this facility is artificially limited to 0.95 PF.



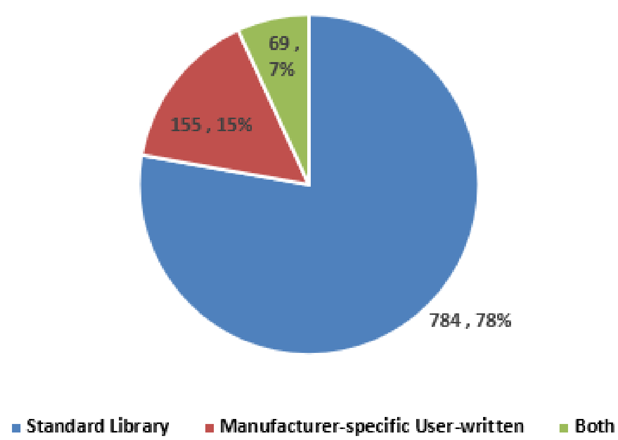


User-Defined Model Submission

A key Worksheet question for GOs was "***Which model type have you submitted to represent your facility model data to your Transmission Planner or Planning Coordinator?"*** GOs had three options to choose from: standard library (such as WECC models), manufacturer-specific (user written) models, or both.

While NERC guidance and FERC Order No. 2023 indicate that both should be submitted, only a small percentage of facilities are currently observing these directions.

Model Type	# of Facilities	%
Standard Library	784	78%
Manufacturer-specific User-written	155	15%
Both	69	7%
Total	1,008	100%

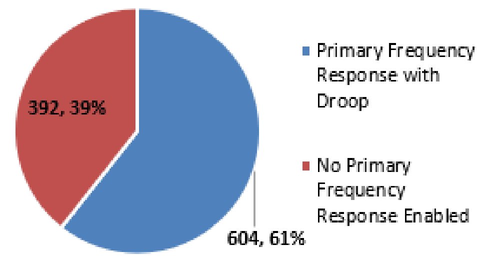


Models Reflecting Reported As-Left Control Mode and Parameters

Mismatches between as-left control settings and model parameters can lead to inaccurate dynamic studies results, therefore, rendering them ineffective at predicting potential stability and reliability impacts. As-left control settings[10] were compared with model parameters that GOs reported. The analysis below was performed on the facilities that submitted a standard library model to TPs or PCs.

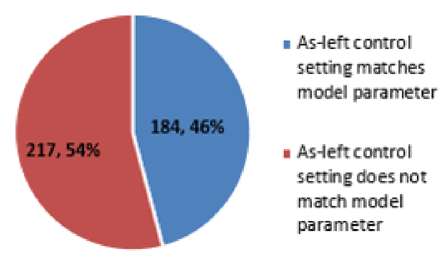
Question 9 asked for normal active power or frequency dependent operation mode. GOs had two options: primary frequency response with droop or no primary frequency response enabled. The answer was compared with the corresponding dynamic model parameter.

Frequency Response Settings	# of Facilities	%
Primary Frequency Response with Droop	604	61%
No Primary Frequency Response Enabled	392	39%
Total	996	100%

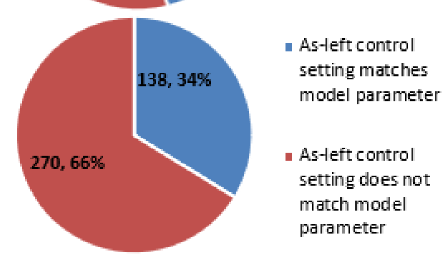


Entities that employed primary frequency response with droop were asked two follow-up questions regarding their frequency deadband and frequency droop settings. These statements were then compared to the actual model settings that the entity submitted. For a response to be considered valid for this tabulation, the entity needed to submit valid entries in both sections of the Worksheet and indicate that primary frequency response with droop is used.

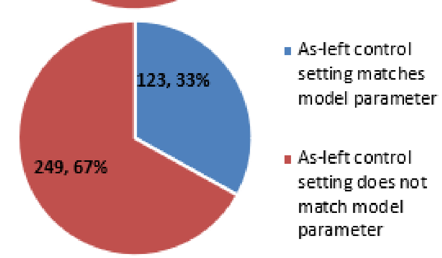
Frequency Deadband Settings Model vs Reported	# of Facilities	%
As-left control setting matches model parameter	184	46%
As-left control setting does not match model parameter	217	54%
Total	401	100%



Downward Regulation Droop Model vs Reported	# of Facilities	%
As-left control setting matches model parameter	138	34%
As-left control setting does not match model parameter	270	66%
Total	408	100%



Upward Regulation Droop Model vs Reported	# of Facilities	%
As-left control setting matches model parameter	123	33%
As-left control setting does not match model parameter	249	67%
Total	372	100%



Models Reflecting Reported As-Left Inverter Trip Settings

Mismatches between as-left inverter trip settings and those in the models can lead to models predicting incorrect IBR ride-through behavior and system stability following contingencies. The following sections help to reflect the comparison of model data to the reported as-left inverter settings.

Modeling Data Consistency

Modeling data provided by the GOs was cross-checked with their modeling data within the dynamic modeling data files (e.g., .dyr and .dyd files). This analysis was performed on data submitted for 150 IBR.

The following table summarizes the key parameters that were checked for consistency. The GO Field value is the value entered by GO in the Worksheet on the "2-Data Submission GO" sheet" sheet. The GO Model (manual entry) value is the value entered by the GO in the "Q7-Model Data" sheet. The GO Model (.dyd/.dyr file) value is the value retrieved from the .dyd (Western Interconnection) or .dyr (Eastern and Texas Interconnections) files submitted. The MOD-032 Case (.dyd/.dyr file) value is retrieved from the Interconnection-wide dynamics data files that NERC receives from the Interconnection-wide case building entities through R4 of MOD-032.

Data Sources and Values Compared				
Model Parameter	**GO Field**	**GO Model** *(manual entry)*	**GO Model** *(dyd/dyr file)*	**MOD-032 Case** *(dyd/dyr file)*
PFR *(flag, droop, db)*	Q9, Q9a, Q9b	Q7	*(dyd/dyr file)*	*(dyd/dyr file)*
VRT *(HVRT/LVRT mode enter)*	Q12, Q12a	Q7	*(dyd/dyr file)*	*(dyd/dyr file)*

The following sections and tables summarize the results of the analysis for each model parameter listed above. The comparisons show the matches between the various data sources and their values in percents.

PFR Flag (on/off)

The first model parameter analyzed the primary frequency response flag (on/off). This flag determines if the frequency control loop will be used in the plants control system. In other words, the flag determines whether the unit will respond to deviations in frequency by adjusting its real power output. A generally good match is seen between the various sources, with the largest disparity between the GO Model Manual Entry and the Interconnection-wide model.

Primary Frequency Response Flag (on/off)			
Data Source	GO Field Manual Entry	GO Model Manual Entry	GO Model Dynamic Model File
GO Model Manual Entry	90%		
GO Model Dynamic Model File	87%	96%	
Interconnection-Wide Model Dynamic Model File	87%	81%	84%

PFR Down Droop Gain (DDN)

The next model parameter analyzed the primary frequency response down droop gain (DDN). This gain determines the magnitude of frequency response (measured in per unit real power) to deviations in frequency from the plant. The DDN specifically controls the frequency response of the plant when frequency is above nominal and outside of the deadband. The largest match occurred between the GO Model Manual Entry and the GO Model Dynamic File. In all other cases, there was a significant mismatch of the values.

Down Droop Gain (DDN)			
Data Source	GO Field Manual Entry	GO Model Manual Entry	GO Model Dynamic Model File
GO Model Manual Entry	44%		
GO Model Dynamic Model File	40%	69%	
Interconnection-Wide Model Dynamic Model File	30%	31%	45%

PFR Up Droop Gain (DUP)

The next model parameter analyzed the primary frequency response up droop gain (DUP). This gain determines the magnitude of frequency response (measured in per unit real power) to deviations in frequency from the plant. Similar to the DDN section above, there were significant mismatches between the various sources. However, the table demonstrates that the DUP parameter is generally consistent between the GOs Dynamic Model file and the Interconnection-wide model files.

Up Droop Gain (DUP)			
Data Source	**GO Field Manual Entry**	**GO Model Manual Entry**	**GO Model Dynamic Model File**
GO Model Manual Entry	42%		
GO Model Dynamic Model File	41%	69%	
Interconnection-Wide Model Dynamic Model File	46%	50%	70%

PFR Deadband 1 (Low Frequency)

The next model parameter analyzed the primary frequency response deadband 1, the low frequency deadband. This deadband prevents the plant controller from commanding the IBR plant to increase real power output until the grid frequency drops below the defined threshold. The largest match of low frequency deadband is between the GO Dynamic Model file and the Interconnection-wide model file. When compared to the Worksheet entries, however, there was a significant mismatch.

Frequency Deadband 1 (under 60.0 Hz)			
Data Source	**GO Field Manual Entry**	**GO Model Manual Entry**	**GO Model Dynamic Model File**
GO Model Manual Entry	43%		
GO Model Dynamic Model File	42%	54%	
Interconnection-Wide Model Dynamic Model File	35%	45%	68%

PFR Deadband 2 (High Frequency)

The next model parameter analyzed the primary frequency response deadband 2, the high frequency deadband. This deadband prevents the plant controller from commanding the IBR plant to decrease real power output until the grid frequency rises above the defined threshold. Like the low frequency deadband, the only significant match of data sources was between the Interconnection-wide Dynamic File and the GO Dynamic File. All other comparisons demonstrated a significant mismatch

Frequency Deadband 2 (over 60.0 Hz)			
Data Source	**GO Field Manual Entry**	**GO Model Manual Entry**	**GO Model Dynamic Model File**
GO Model Manual Entry	42%		
GO Model Dynamic Model File	40%	51%	
Interconnection-Wide Model Dynamic Model File	33%	44%	70%

Low Voltage Ride-through Enter (Vdip)

The next model parameter analyzed voltage ride-through mode enter (Vdip) for low voltage. This per-unit voltage parameter determines at which voltage the electrical controller enters voltage ride-through mode. This has a significant impact on the current injection. The Vdip parameter shows great match between Dynamic Model files and some GO Dynamic files and the Interconnection-wide file; however, the manual entry of the field settings does not match a significant portion of the Dynamic File data.

Low Voltage Ride-through Enter (Vdip)			
Data Source	**GO Field Manual Entry**	**GO Model Manual Entry**	**GO Model Dynamic Model File**
GO Model Manual Entry	35%		
GO Model Dynamic Model File	38%	93%	
Interconnection-Wide Model Dynamic Model File	27%	67%	69%

High Voltage Ride-through Enter (Vup)

The next model parameter analyzed the voltage ride-through mode enter (Vup) for high voltage. This per-unit voltage parameter determines at which voltage the electrical controller enters voltage ride-through mode. This has a significant impact on the current injection. Similar to the Vdip parameter, the Vup parameter is consistent among Dynamic File representations but diverges from the as-left field settings.

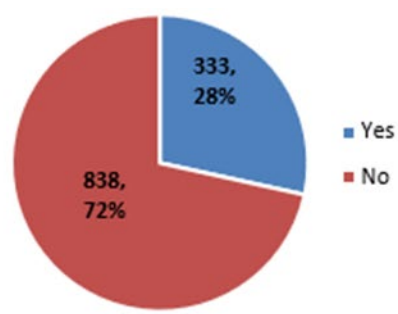
High Voltage Ride-through Enter (Vup)			
Data Source	**GO Field Manual Entry**	**GO Model Manual Entry**	**GO Model Dynamic Model File**
GO Model Manual Entry	44%		
GO Model Dynamic Model File	52%	95%	
Interconnection-Wide Model Dynamic Model File	37%	61%	66%

Although dynamic model data was also collected from TPs and PCs, it was challenging to map a specific IBR plant to a specific TP or PC due to insufficient information requested. Therefore, GO model data was instead compared with interconnection-wide case modeling data. The tables above could be augmented by the TP or PC dynamic model data; however, NERC is confident that the mismatches identified in the tables above demonstrate significant breakdown in the IBR model’s ability to represent as-left or as-build parameters in the field as reported in the Worksheet.

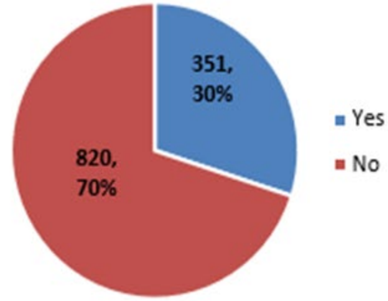
Protection Settings with Respect to Equipment Capabilities

Generation models are used to evaluate specific performance in a planning simulation, particularly if the credible contingencies create a situation where generation may trip in response to the simulated system conditions. In the Worksheet, GOs were asked whether the high and low voltage and frequency protection settings were based on the maximum capability of the inverter. The following charts share how the settings in the field relate to the equipment’s maximum capability.

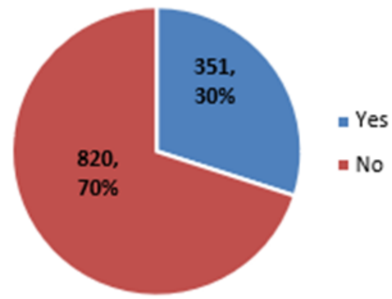
HVRT Settings at Max Capability	# of Facilities	%
Yes	333	28%
No	838	72%
Total	1,171	100%



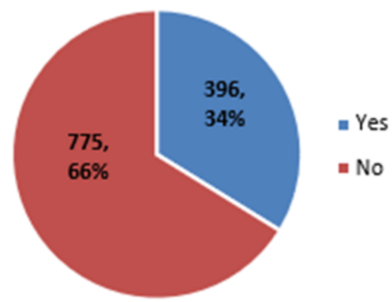
LVRT Settings at Max Capability	# of Facilities	%
Yes	351	30%
No	820	70%
Total	1,171	100%



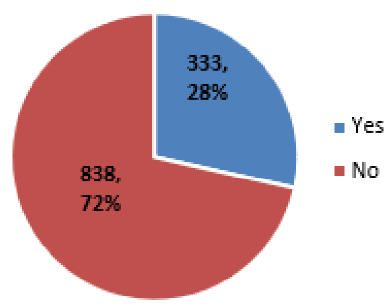
Overvoltage Settings at Max Capability	# of Facilities	%
Yes	351	30%
No	820	70%
Total	1,171	100%



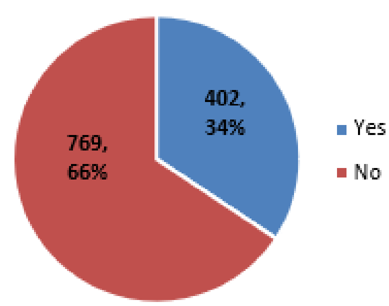
Undervoltage Settings at Max Capability	# of Facilities	%
Yes	396	34%
No	775	66%
Total	1,171	100%



HFRT Settings at Max Capability	# of Facilities	%
Yes	409	35%
No	762	65%
Total	1,171	100%



LFRT Settings at Max Capability	# of Facilities	%
Yes	402	34%
No	769	66%
Total	1,171	100%



It is clear that most protection settings in the field are not based on equipment capabilities. This indicates that there may be a portion of a generator's capability that is unused to ride-through voltage or frequency excursions. While protection design may require margins to ensure equipment or personnel safety, artificially lowering the capability of generation ride-through by setting more restrictive protection settings will interfere with a system's ability to recover from a disturbance and settle to a secure post-disturbance state

Next Steps

Based on the findings from this alert and the previous alert on IBR performance, a Level 3 alert with Essential Actions is needed to address the deficiencies observed.