NERC-NASPI IBR Workshop

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Odessa 2 – Lessons Learned
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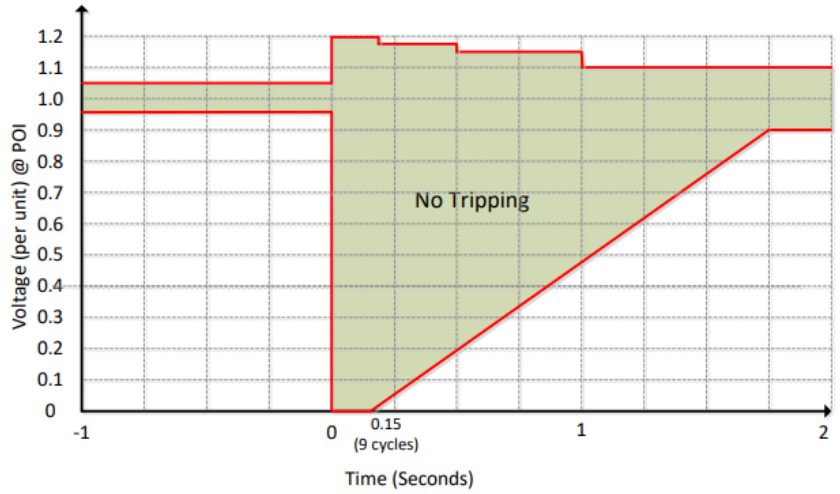
2022 Odessa Disturbance Event Overview

- Event initiated by lightning arrestor failure occurred in the Odessa area of West Texas
- Fault occurred on June 4th at 12:59:25 PM
- Estimated loss of 2,560 MW of thermal and IRR generation
  - ➢1,709 MW of IRR generation reduction from 14 solar facilities
  - ➢851 MW of thermal generation reduction
- System Frequency declined to 59.700 Hz and recovered to 60 Hz in 1 min 20 sec
- 1,227 MW of Responsive Resource Service (RRS) deployed
- 1,116 MW of Load Resources deployed
- Categorized as NERC Cat 3a event (gen loss > 2000 MW)

Real Time PMU Voltage

- Lowest recorded voltage of 0.714pu from PMU in Odessa area on 345 kV line
- Highest recorded voltage of 1.102pu from PMU in Del Rio area on 138 kV line
- Faults cleared in ~3 cycles
- Attempted and failed reclose of a line in the Odessa area~10 seconds later
- Within VRT “No Tripping” zone in NOG 2.9.1
  - i.e. resources are expected to ride-through the event



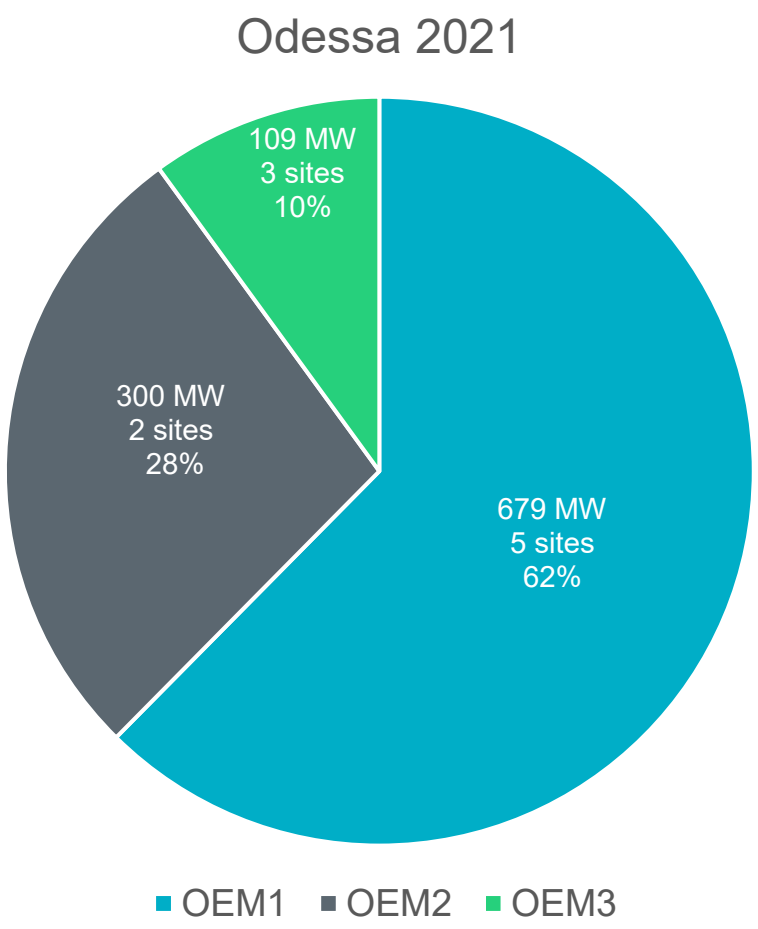
Real Time PMU Frequency

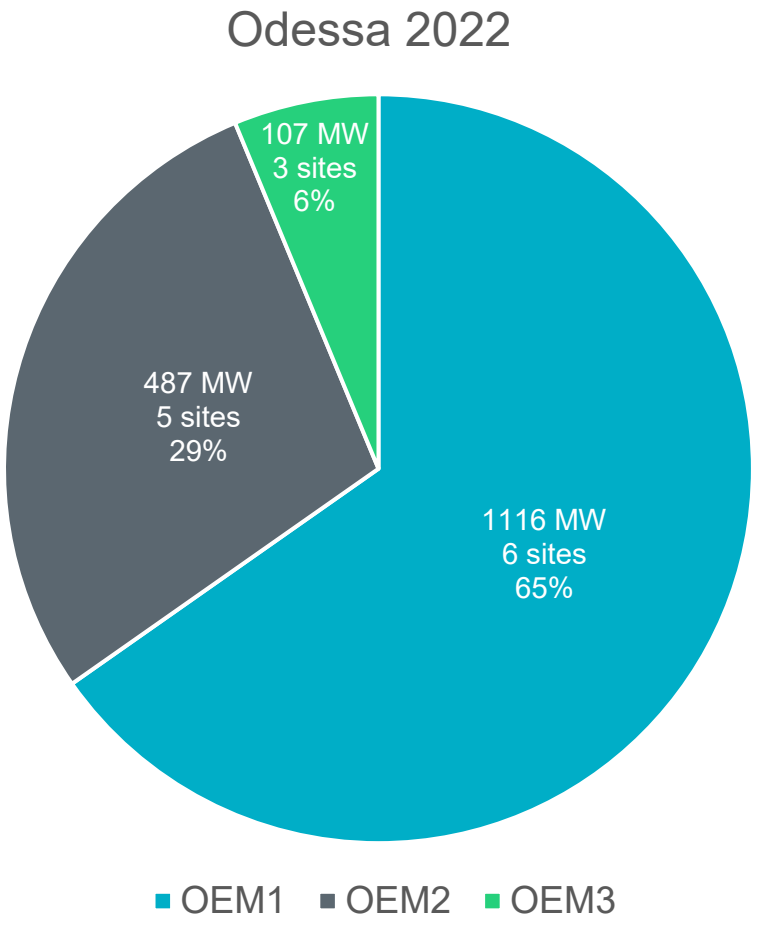
- Most PMUs lowest freq. of 59.7 Hz after LOG
- Single PMU near Laredo had lowest freq. of 59.62 Hz
- Couple other PMUs in South dipped below 59.7 Hz
- Local transient freq. seen as low 58.83 Hz and high as 60.26 Hz in Far West
- Protection settings should not be set on transient freq.

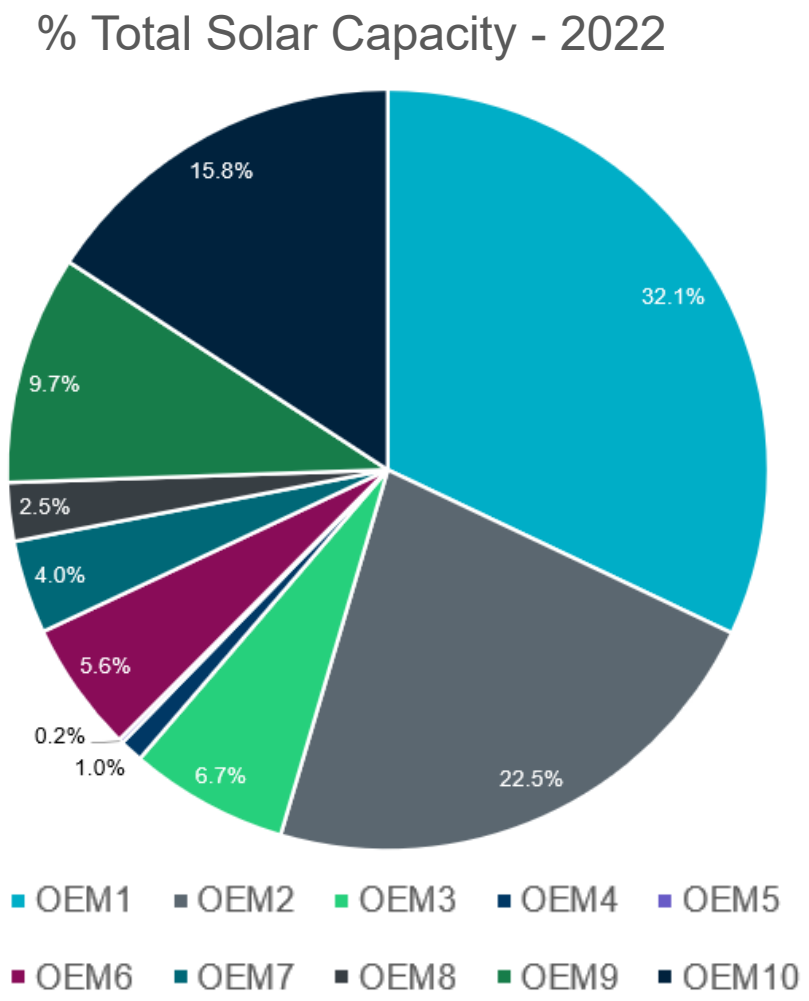
Solar Generation Loss

- 14 solar generation sites consisting of 19 units lost >10 MW
  - Total estimated generation loss of 1,709 MW vs. 1,112 MW in Odessa event 2021
  - Does not include generation that came back within 1 sec of fault clearing
- 9 of the 14 sites lost generation in Odessa event May 2021
  - 8 of the 9 sites were identified in NERC Odessa Disturbance report (10 total facilities identified in report)
  - Remaining 5 either in commissioning, offline, or rode through

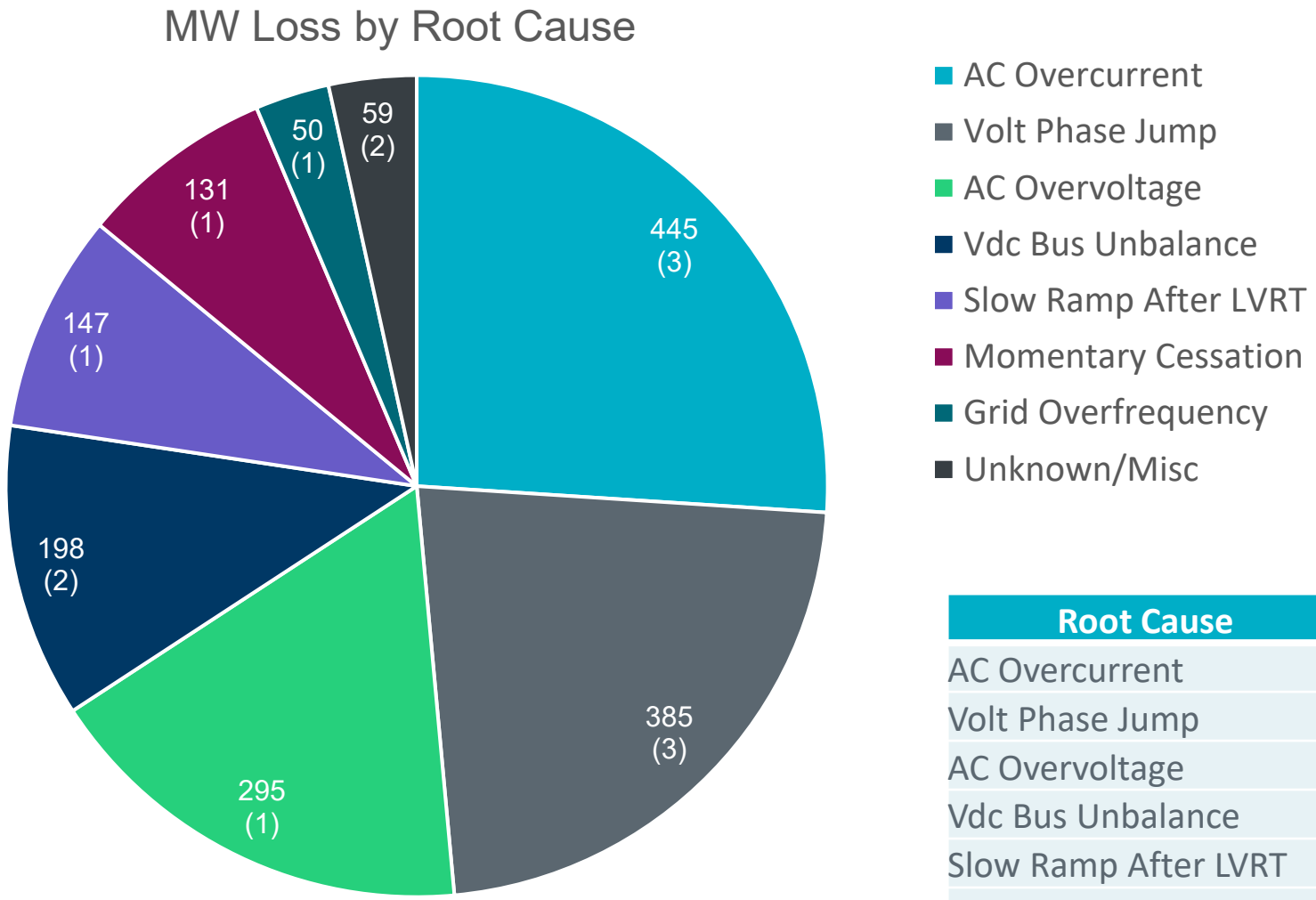
MW Loss per Inverter Type and Capacity







Causes of Solar PV Reduction – 2022 Odessa



Root Cause	# Affected Facilities	MW Loss
AC Overcurrent	3	445
Volt Phase Jump	3	385
AC Overvoltage	1	295
Vdc Bus Unbalance	2	198
Slow Ramp After LVRT	1	147
Momentary Cessation	1	131
Grid Overfrequency	1	50
Unknown/Misc	2	59

PMU Requirements – Data Recording

6.1.3 Phasor Measurement Recording Equipment Including Dynamic Disturbance Recording Equipment

(1) Phasor measurement recording equipment includes all dynamic disturbance recording equipment with phasor measurement recording capability that meet the requirements in Sections 6.1.3.1, Recording and Triggering Requirements, and 6.1.3.3, Data Recording and Redundancy Requirements.

(2) Phasor measurement recording equipment required by these Operating Guides shall be time synchronized with a Global Positioning System-based clock, or ERCOT-approved alternative, with sub-cycle (<1 microsecond) timing accuracy and performance.

(a) Provided in IEEE C37.118.1-2011, IEEE Standard for Synchrophasor format;

(b) A minimum output recording rate of 30 times per second;

(c) A minimum input sampling rate of 960 samples per second; and

(d) Transmitted to an ERCOT phasor data concentrator via a communication link or stored locally per retention requirements in Section 6.1.3.4, Data Retention and Data Reporting Requirements.

PMU Requirements – Location

(4) The facility owner(s), whether a Transmission Facility owner or Generation Resource owner, shall install phasor measurement recording equipment at the following facilities:

(a) Flexible AC transmission system devices configured to actively control steady-state voltage or power transfer capability, operated at or above 100 kV, and energized after July 1, 2015;

(b) Within 18 months after receiving written notice from ERCOT, a Transmission Facility identified by ERCOT associated with each published generic transmission constraint as deemed necessary by ERCOT;

(c) New generating facilities over 20 MVA aggregated at a single site placed into service after January 1, 2017; and

Potential Expansion

- ERCOT was proactive in requiring every facility with a COD after 2017 to have PMUs installed, however if older units continue to have issues ERCOT may require PMUs to be installed

Current PMU Requirements – Data Retention Requirements

6.1.3.4 Data Retention and Data Reporting Requirements

(1) The minimum recorded electrical quantities shall be retained per the following guidelines:

(a) Rolling ten calendar day window for all data stored locally and not transmitted to an ERCOT phasor data concentrator;

(b) Minimum three year data retention by the Generation Resource owner for event data utilized for model validation in accordance with NERC Reliability Standards; and

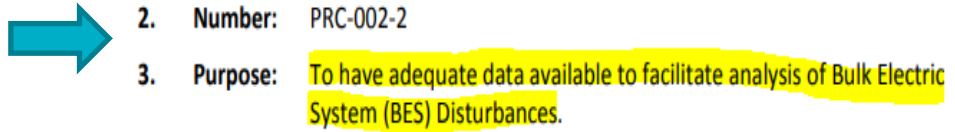
(c) Minimum three year data retention by the Generation Resource owner or Transmission Facility owner for event data provided to ERCOT, the NERC Regional Entity, or NERC via written request that is recorded in the context of an ERCOT-, NERC Regional Entity-, or NERC-initiated disturbance analysis or event review.

Potential Expansion

- Looking to make some additional enhancements to data retention requirements
  - Possibly expanding 10-day storage requirement to 20-30 days

Digital Fault Recorder (DFR) Requirements

- ERCOT already has strict requirements for DFR data outlined in section 6.1.2 of the ERCOT Nodal Operating Guides
- These requirements are inline with or exceed NERC PRC-002
- If ERCOT needs additional DFR data at locations that are not currently covered in the Nodal Operating Guides, we may make some language changes in the future to install DFRs at locations where problems are continuing to occur



1. **Title:** Disturbance Monitoring and Reporting Requirements
2. **Number:** PRC-002-2
3. **Purpose:** To have adequate data available to facilitate analysis of Bulk Electric System (BES) Disturbances.

Adoption of IEEE 2800

- ERCOT has worked with EPRI to identify gaps between ERCOT rules and IEEE 2800
- ERCOT stakeholder rules being reviewed consist of ERCOT Protocols, Operating Guides, Planning Guides, and Modeling Quality Guides.
- Any important existing gaps have been prioritized to focus on higher priority gaps first.
- ERCOT is doing a piecemeal implementation to edit our rules rather than a wholesale adoption of 2800 that in all will be a multi-year effort.
- ERCOT stakeholder rule changes typically take several months to pass depending on urgency.
- The first priority of rule changes will require reactive capability at 0 MW output due to interconnection queue of mostly IBRs.
- The second priority of rule changes will improve the clarity and specificity of the frequency and voltage ride-through requirements while aligning with IEEE 2800. This would focus on those ride-through requirements that would have the most impact based on Odessa Event causes.

Preliminary High-Level Gap Assessment of ERCOT Nodal Protocols

Legend: X Prohibited, √ Allowed by Mutual Agreement, ‡ Capability Required, NR No Explicit Requirement
(‡) Procedural Step Required as specified, Δ Test and Verification Defined, !!! Important Gap

Acknowledgements for contributions and peer-review: Julia Matevosyan (ESIG)

Function Set	Advanced Functions Capability	ERCOT Nodal Protocols	IEEE 2800-2022
General	Definitions	?	?
	Sec 4 Reference Point of Applicability	POI	POM
	Adjustability in Ranges of Available Settings	NR (!!!)	‡
	Prioritization of Functions	‡	‡
Monitoring, Control, and Scheduling	Ramp Rate Control		
	Sec 11 Communication Interface	‡	‡
	Disable Permit Service (Remote Shut-Off, Remote Disconnect/Reconnect)	‡	‡
	Limit Active Power	‡	‡
	Monitor Key Data	‡	‡
	Remote Configurability		√
	Set Active Power	‡	√
	Sec 5 Scheduling Power Values	‡	√
Reactive Power & (Dynamic) Voltage Support	Constant Power Factor	‡	‡
	Voltage-Reactive Power (Volt-Var)	‡	‡
	Autonomously Adjustable Voltage Reference	?	
	1 Capability at zero active power ("VArs at night")	NR (!!!)	‡
	Active Power-Reactive Power (Watt-Var)		
	Constant Reactive Power	NR (!!!)	‡
	Voltage-Active Power (Volt-Watt)	NR	NR
	2 Dynamic Voltage Support / Current Injection during VRT — Balanced	‡	‡
	2 Dynamic Voltage Support / Current Injection during VRT — Unbalanced	NR (!!!)	‡

Function Set	Advanced Functions Capability	ERCOT Nodal Protoc.	IEEE 2800-2022
Bulk System Reliability & Frequency Support	2 Frequency Ride-Through (FRT)	‡	‡
	Sec 6&7 2 Rate-of-Change-of-Frequency (ROCOF) Ride-Through	NR (!!!)	‡
	Voltage Ride-Through (VRT)	‡	‡
	2 Transient Overvoltage Ride-Through	√ (!!!)	‡
	2 Consecutive Voltage Dip Ride-Through	NR (!!!)	‡
	2 Restore Output After Voltage Ride-Through	NR (!!!)	‡
	2 Voltage Phase Angle Jump Ride-Through	NR (!!!)	‡
	Frequency Droop / Frequency-Watt	‡	‡
	3 Fast Frequency Response / Inertial Response — Underfrequency FFR	√ (!!!)	‡
	3 Fast Frequency Response / Inertial Response — Overfrequency FFR	NR	√
	Return to Service (Enter Service)	?	‡
	Sec 9 Black Start	NR	√
Protection Functions and Coordination	Abnormal Frequency Trip	NR	√
	Rate of Change of Frequency (ROCOF) Protection	?	√
	Abnormal Voltage Trip	NR	√
	AC Overcurrent Protection	?	√
	Unintentional Islanding Detection and Trip	NR	√
	Sec 8 Interconnection System Protection	?	√
Power Quality	Limitation of DC Current Injection		
	Limitation of Voltage Fluctuations	NR (!!!)	‡
	Limitation of Current Distortion	NR (!!!)	‡
	Limitation of Voltage Distortion	NR	√
	Limitation of (Transient) Overvoltage	NR (!!!)	‡

Thirteen (13) high-level gaps in ERCOT relate to 2800 mandatory requirements

ERCOT Protocols change requiring Reactive Capability at 0 MW output for IBRs

- Drafts are complete and undergoing a final review with an estimated 2-3 weeks to time of submission to begin the stakeholder review process.
- Addresses other clarifications and requirements needed to support this requirement
  - (e.g. removal of previous exemption below 10%, new reactive capability tests at 0 MW)
- Aligns with or exceeds applicable parts of IEEE 2800 requirements where appropriate
  - (e.g. ERCOT requires reactive capability at POI vs POM).
- Some effort shifted to further expedite the voltage and frequency ride through requirements based on feedback from a recent ERCOT Inverter Based Resource Task Force (IBRTF) meeting

IBR Ride-Through Requirements

- ERCOT Operating Guide Sections 2.6 and 2.9 to be revised.
- Initial Draft is complete and past technical review. Second review is now ongoing with an estimated 3-4 weeks to time of submission to begin the stakeholder review process.
- Addresses both frequency ride-through and voltage ride-through of Inverter Based Resources (IBRs)
- Aligns with or exceeds applicable parts of IEEE 2800 requirements where appropriate
  - (e.g. ERCOT is proposing 45 degrees of phase angle jump ride through capability vs 25)
- Includes language that addresses most of the ride-through failure modes
- Includes language that clarifies certain specific aspects of ride-through performance requirements with additional specificity where appropriate.

Questions?