

# 2022 Odessa Disturbance Update

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#### **2022 Odessa Disturbance Event Overview**

- On June 4, 2022, @ 12:59 PM CDT, Phase-B to ground fault occurred due to lightning arrestor failure in the Odessa area
- Fault cleared within 3 cycles, consequentially tripping off 542 MW of thermal generation
- Additional 309 MW lost from combined cycle plant in South Texas
- Non-consequential loss of 1,709 MW of solar generation from 14 different sites following the fault
- Combined loss of 2,560 MW of generation
- 1,116 of Load Resources provided Responsive Reserve Service automatically
- Categorized as NERC Cat 3a event (generation loss > 2000 MW)



#### **MW Loss per Inverter Type and Capacity**



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#### **Causes of Solar PV Reduction – 2022 Odessa**

#### MW Loss by Root Cause



AC Overcurrent

- Volt Phase Jump
- AC Overvoltage
- Vdc Bus Unbalance
- Slow Ramp After LVRT
- Momentary Cessation
- Grid Overfrequency
- Unknown/Misc

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

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# OEM1 MW Loss by Root Cause





# Affected Facilities	MW Loss
3 (2 OEM1)	445
3	385
1	295
2	198
1	147
1	131
1	50
2	59
	# Affected Facilities      3 (2 OEM1)      3      1      2      1      1      1      2      1      2      1      2      3



# **OEM1 - Overcurrent**





- Follow up call with OEM1 and RE (same for both sites) week Sept. 1
- Cannot increase overcurrent protection thresholds due to potential damage to inverter IGBTs
- OEM1 developing algorithm to prevent current spikes during grid voltage disturbances (in testing)
- RE to develop mitigation plan and timeline to submit to ERCOT



# **OEM1 - Overvoltage**





- Follow up call with OEM1 and RE week Sept. 1
- OEM1 increasing fast overvoltage protection thresholds (rollout has begun on some sites)
- OEM1 recommends decreasing k factor of DVC from 2 to 1 (default for new projects set to 1) to prevent overvoltage upon fault clearing
- RE to develop mitigation plan and timeline to submit to ERCOT

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# **OEM1 - Volt Phase Jump**



- Follow up calls with OEM1 and all 3 REs week of August 22
- Anti-islanding protection primarily used in distribution to protect lineman
- Protection not required on BPS nor for inverter protection
- Anti-islanding protection required for UL 1741 certification
- OEM1 recommends either extending threshold from 15 to 35 degrees or disabling protection altogether
- GO must request changes to volt phase jump protection settings
- REs to develop mitigation plan and timeline to submit to ERCOT



#### **NERC 2021 Odessa Disturbance Report**

	Table B.1: Review of Solar PV Facilities										
Facility ID	Capacity [MW]	Reduction [MW]	POI Voltage [kV]	In-Service Date	Highest Data Resolution	NERC-Texas RE Review					
Plant A	180	28	138	6/2018	PMU	Unable to identify root cause due to lack of data.					
Plant B	152	150	138	6/2020	PMU	All inverters at site tripping on PLL loss of synchronism. Anomalous reactive power injection after inverter tripping.					
Plant C	126	64	345	11/2020	DER	Some inverters at plant tripped on AC overvoltage. Inverters injected reactive current during fault conditions. Inverter voltage reached trip					
Plant D	132	04	345	11/2020	DIK	settings of 1.25 pu and tripped instantaneously. POI voltage experienced voltage below nominal at this time.					
Plant E	162	21	138	5/2021	1-sec	One medium voltage feeder breaker tripped instantaneously on measured underfrequency of 57.5 Hz, disconnecting 25 inverters.					
Plant F	50	48	69	9/2017	1-sec	All inverter at facility tripped off-line. Those that indicated a fault code tripped on "grid underfrequency" conditions.					
Plant G	121	239	345	12/2019	PMU	All inverters at the facility tripped. The vast majority tripped on PLL loss of synchronism, while the others had an unidentified cause for					
Plant H	119					tripping.					
Plant I	154	205	345	6/2020	Inverter High-	Inverter instantaneous ac overvoltage tripping over 1.3 pu. Induced by inverter injection of reactive current into high voltage conditions post-					
Plant J	150	205	345	6/2020	Speed	fault.					
Plant K	78.75	150	138	9/2016	DER	Legacy inverter momentary cessation setting with plant-level					
Plant L	78.75	135	138	9/2016	DFK	recovery.					
Plant M	155	147	138	3/2018	DFR	Plant injected reactive current into high voltage condition, causing all feeder breakers to trip on instantaneous ac overvoltage.					
Plant N	110	22	138	3/2017	2 500	Unknown cause of reduction in active power reduction (increase in reactive power output); interactions of primary frequency response controls with plant recovery.					
Plant O	50	23	138	11/2016	2-sec	Reduction in active power output caused by inverter controls; response to pre-disturbance in about 20-30 seconds does not meet NERC guidelines.					
Other		34				Not analyzed.					
TOTAL		1,112									

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## **Solar Farms with OEM1 Inverters**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant B*	150	PLL Loss of Synchronism	Function Disabled	133	Volt Phase Jump	Volt Phase Jump Disabled; VRT thresholds increased; DVC k-factor reduced	9/30/2022
Plant C/D	64	AC Inverter Overvoltage	None by June 2022	56	Volt Phase Jump	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	TBD
Plant E	21	Feeder Breaker Trip - Underfrequency	Increased measurement window to 10 cycles – after June 2022	295	AC Inverter Overvoltage	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	TBD; work began 10/17
Plant I/J	205	AC Inverter Overvoltage	None by June 2022	196	Volt Phase Jump	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	10/28/2022
Plant P	N/A	N/A	N/A	176	AC Overcurrent	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	TBD; work began 10/17
Plant T	N/A	N/A	N/A	259	AC Overcurrent	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	TBD; work began 10/17

#### \*NERC Odessa Disturbance Report Table B.1



# **Solar Farms with OEM1 Inverters – Plant B**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant B	150	PLL Loss of Synchronism	Function Disabled	133	Volt Phase Jump	Volt Phase Jump Disabled; VRT thresholds increased; DVC k-factor reduced	9/30/2022

- Overcurrent mitigation already exists in this inverter model
- Volt Phase Jump disabled
- OVRT protection thresholds increased
  - ▶ 125% @ 0 sec
  - ▶ 120% @ 10 sec
  - ➤ 112% @ 15 sec
- DVC k-factor decreased from 2 to 1
- All work complete by 9/30/2022
- No follow up for corrective action implementation
- Will need to resubmit models and currently in process





# **Solar Farms with OEM1 Inverters – Plant C/D**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant C/D	64	AC Inverter Overvoltage	None	56	Volt Phase Jump	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	TBD

- In process of modeling k-factor reduction in June 2022
- Volt Phase Jump threshold to be increased from 15 to 35 degrees
- OVRT protection thresholds to be increased
  - > 140% @ 0 sec (momentary cessation >1.25 pu)
  - ▶ 120% @ 2sec
  - ➤ 110% @ 30 sec
- DVC k-factor to be decreased from 2 to 1
- Waiting on OEM to complete testing on overcurrent mitigation
- Waiting on OEM to schedule implementation date
- Will need to resubmit models





# Solar Farms with OEM1 Inverters – Plans E, P, and T

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant E	21	Feeder Breaker Trip - Underfrequency	Increased measurement window to 10 cycles – after June 2022	295	AC Inverter Overvoltage	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	TBD; work began 10/17
Plant P	N/A	N/A	N/A	259	AC Overcurrent	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	TBD; work began 10/17
Plant T	N/A	N/A	N/A	176	AC Overcurrent	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	TBD; work began 10/17

- Same personnel for all three facilities
- Work began on 10/17 to be complete by 12/7 ERCOT waiting on update on completed work
- Volt Phase Jump threshold to be increased from 15 to 35 degrees
- OVRT protection thresholds increased 140% @ 0 sec; 120% @ 2 sec; 110% @ 30 sec
- DVC k-factor decreased from 2 to 1
- 3 feeder breakers tripped at 2 sites due to underfrequency frequency measurement window increased to 10 cycles at all three sites (breakers and inverters)
- Waiting on overcurrent mitigation and models will need to be resubmitted



# **Solar Farms with OEM1 Inverters – Plant I/J**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant I/J	205	AC Inverter Overvoltage	None by June 2022	196	Volt Phase Jump	VPJ threshold increased; VRT thresholds increased; DVC k-factor reduced	10/28/2022

- In process of modeling k-factor reduction in June 2022
- Volt Phase Jump threshold increased from 15 to 35 degrees
- OVRT protection thresholds increased
  - > 140% @ 0 sec (momentary cessation >1.25 pu)
  - ▶ 120% @ 1 sec
  - ▶ 110% @ 65 sec
- DVC k-factor decreased from 2 to 1
- Waiting on OEM to complete testing on overcurrent mitigation
- All other work confirmed complete on 10/28
- Will need to resubmit models







# **OEM2 MW Loss by Root Cause**

OEM2 MW Loss by Root Cause



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 (1)	59 (12)



## **Solar Farms with OEM2 Inverters**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant K/L	153	Momentary Cessation	Replaced PPC to improve recovery	131	LVRT disabled; loss of auxiliary power	LVRT/momentary cessation enabled	??
Plant M	147	Feeder Tripping - Overvoltage	Feeder overvoltage protection disabled	147	LVRT disabled; Slow recovery	LVRT/OVRT enabled; Changed LVRT mode; OVRT threshold increased; DVC k-factor reduced	Work completed in October
Plant Q	N/A	N/A	N/A	104	Vdc Bus Unbalance	Software update to improve DC regulation	TBD
Plant S	N/A	N/A	N/A	12	IGBT Overcurrent; High inverter temperature	Unknown; logging error – replaced SD cards	In process
Plant U	N/A	N/A	N/A	94	Vdc Bus Unbalance	Software update to improve DC regulation	8/29/2022

\*NERC Odessa Disturbance Report Table B.1



#### **Solar Farms with OEM2 Inverters – Plant K/L**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant K/L	153	Momentary Cessation	Replaced PPC to improve recovery	131	LVRT disabled; loss of auxiliary power	LVRT/momentary cessation enabled	??

- LVRT/Momentary Cessation disabled during Odessa 2 event
- Loss of auxiliary power and/or phase jump > 20 degrees caused inverters to reduce output – inverter must reset and begin ramping to slower ramp rate
- LVRT/Momentary Cessation has been reenabled
- Momentary Cessation when voltage < 0.9pu
- Should recover to pre-disturbance output in < 1 sec
- Inverters will not ride-through large phase shifts or ROCOF
- Inverters will not provide reactive during LVRT
- Facility does not meet NOG VRT requirements





# **Solar Farms with OEM2 Inverters – Plant M**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant M	147	Feeder Tripping - Overvoltage	Feeder overvoltage protection disabled	147	LVRT disabled; Slow recovery	LVRT/OVRT enabled; Changed LVRT mode; OVRT threshold increased; DVC k-factor reduced	Work completed in October

- LVRT disabled during Odessa 2 event
- Slower inverter ramp rate and PPC interaction caused slow recovery
- LRVT has been enabled
- Changed LVRT mode to limit active power reduction
- Increased fast overvoltage inverter protection to 1.35pu
  @ 0.5 sec
- DVC k-factor changed to 1
- All work completed in October
- Will need to resubmit model and currently in process







- Protection occurs when DC-side positive and negative bus voltage becomes unbalanced very rapidly potential short
- AC-side voltage phase became unbalanced faster than controls could regulate DC-side due to disturbance
- OEM2 had seen issue in previous events and were already testing software update to mitigate
- Software update improves DC bus regulation response time during voltage disturbances
- OEM completed update to one plant on Aug. 29; second plant to be scheduled soon
- Update to be applied to all OEM2 inverters in ERCOT (with one exception)



#### Solar Farms with OEM2 Inverters – Plant Q and Plant U

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant Q	N/A	N/A	N/A	104	Vdc Bus Unbalance	Software update to improve DC regulation	TBD
Plant U	N/A	N/A	N/A	194	Vdc Bus Unbalance	Software update to improve DC regulation	8/29/2022

- Plant Q confirmed all inverters had software update implemented on 8/29/2022
- Plant S working on scheduling implementation date with OEM; potentially next week
- OEM confirmed DC side not modeled
- Models will not need to resubmitted for these facilities







#### **Solar Farms with OEM2 Inverters – Plant S**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant S	N/A	N/A	N/A	12	IGBT Overcurrent; High inverter temperature	Unknown; logging error – replaced SD cards	In process

- 5 out of 83 inverters tripped during Odessa 2 event
  - > 3 inverters due to high internal temperature
  - 2 inverters due to IGBT overcurrent
- Minimal data available for root cause analysis due to SD card constraint
- In process of replacing with higher capacity SD cards
- OEM unable to determine corrective actions for the 5 inverter trips





# **Solar Farms with OEM3 Inverters**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant F	48	Underfrequency – Inverter level	None	47	Unknown	Expanded VRT and FRT settings; Improved inverter logging capabilities	Work completed in October
Plant N/O	23	Unknown	None	50	Unknown; Inaccurate fault code	Expanded VRT and FRT settings; Improved inverter logging capabilities	RT settings 9/29/2022; Logging in process
Plant R	N/A	N/A	N/A	10	IGBT overcurrent	None	N/A

- OEM3 out of business
- Working with company that took over service contracts

#### \*NERC Odessa Disturbance Report Table B.1



# **Solar Farms with OEM3 Inverters – Plant F**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant F	48	Underfrequency – Inverter level	None	47	Unknown	Expanded VRT and FRT settings; Improved inverter logging capabilities	Work completed in October

- 25 of 26 inverters went into standby mode for unknown reason
- Inverter logs overwritten by PPC commands
- RE worked with OEM to set VRT and FRT parameters based on equipment tolerances
  - ➢ FRT set for > 63 Hz or < 57 Hz with 3 sec delay</p>
  - VRT parameters expanded with OVRT2 set at 130%
    @ 60 ms
- Modified code to limit number of commands to prevent overwriting inverter logs
- All work confirmed complete on 11/3
- Will need to resubmit models





# **Solar Farms with OEM3 Inverters – Plant N/O**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant N/O	23	Unknown	None	50	Unknown; Inaccurate fault code	Expanded VRT and FRT settings; Improved inverter logging capabilities	RT settings 9/29/2022; Logging in process

- 38 of 166 inverters tripped on fault code Grid Overfrequency
- Fault code registry table incorrectly mapped
- Cause of inverter tripping unknown
- RE worked with OEM to set VRT and FRT parameters based on equipment tolerances
  - ➢ FRT set for > 63 Hz or < 57 Hz with 3 sec delay</p>
  - VRT parameters expanded with OVRT2 set at 130% @
    60 ms
- All ride-through work complete on 9/29
- OEM currently on-site conforming software version for HMI to current fault code error
- Will need to resubmit models





#### **Solar Farms with OEM3 Inverters – Plant R**

Facility	MW Loss 2021	Root Cause 2021	Corrective Actions	MW Loss 2022	Root Cause 2022	Corrective Actions	Completion Date
Plant R	N/A	N/A	N/A	10	IGBT overcurrent	None	N/A

- 7 out of 79 inverters tripped to IGBT overcurrent protection
- OEM states protection is needed for inverter protection
- OEM has not identified root cause of overcurrent nor any corrective actions
- Next course of action with this facility undecided





#### **Remaining Work and Misc. Information**

- ERCOT report to PUCT has been submitted
- NERC 2022 Odessa Disturbance report likely out next month
- ERCOT to begin reaching out to facilities with same inverters not involved in Odessa events
  - Vdc Unbalance
  - ➢ Volt Phase Jump
  - Extending OVRT settings
  - ➢ Overcurrent mitigation
- ERCOT developing process for model validation and resubmission
  - ➢ Follow up will be required
  - Deadlines need to be established
  - Reporting of non-compliance





