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Wind Generation and Energy Storage Response to a System Under Voltage Event

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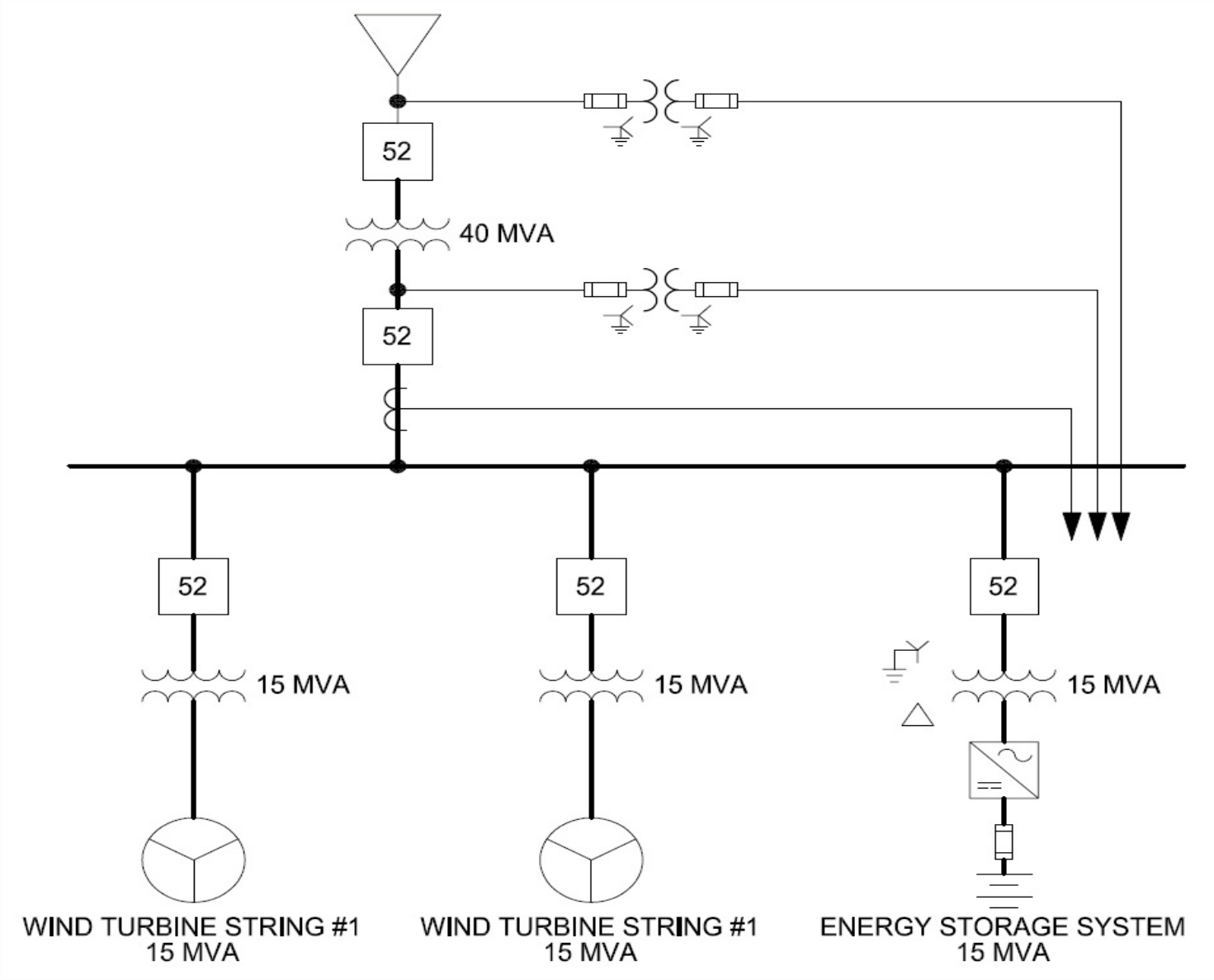
System Overview

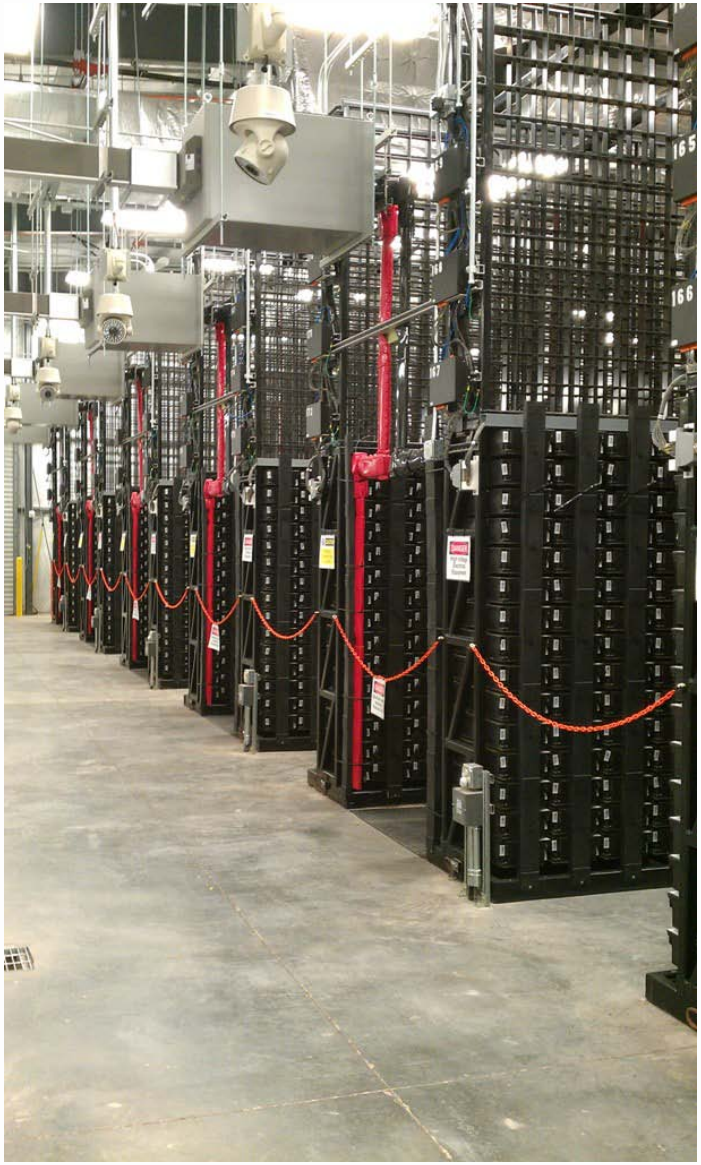
- Location: Hawaiian Island (Oahu)
- Peak Load = 1,200 MW
- Off Peak Load = 600 MW
- Generation Capacity = 1,760 MW
- 30 MW Wind Turbine Generator Facility
- 15MVA Energy Storage System
  - Performing Ramp Rate Control and Voltage Regulation
- Facility Voltage and Frequency Ride Through Requirements defined by a Power Purchase Agreement (PPA)

Undervoltage Ride-Through Requirements	
Range	**Requirement**
0.80 pu ≤ V ≤ 1.00 pu	**Facility shall remain connected**
0.75 pu ≤ V < 0.80 pu	**Facility shall remain connected for 2 seconds**
0.00 pu ≤ V < 0.75 pu	**Facility shall remain connected for 600 milliseconds**

System Single Line Diagram



System Images



System Images cont.

Grid Undervoltage Event Description

- Grid under-voltage condition on February 18, 2012
  - Approximately 0.77 per unit recorded; On boundary of facility ride through requirements
- Caused instantaneous loss of 12.5 MW of Wind Generation
  - Approximately 60% of facility production at time of event
- Energy storage system response with 12.5 MW of active power with ramp down to steady state of 7.5 MW
  - Ramp time pre-determined based on power system spinning reserve ramping ability
- Energy storage system response of 1.3 MVAR for system voltage support

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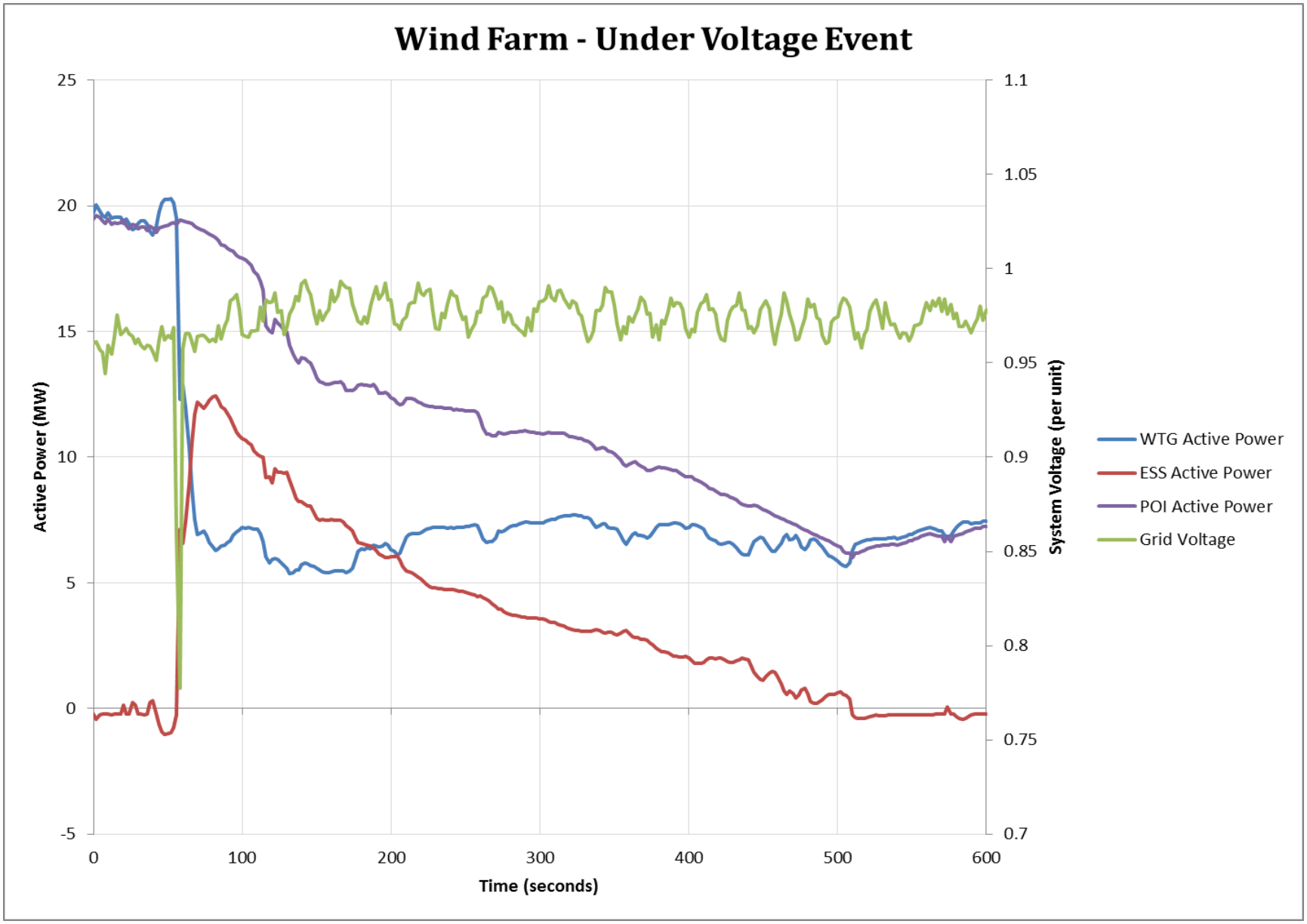
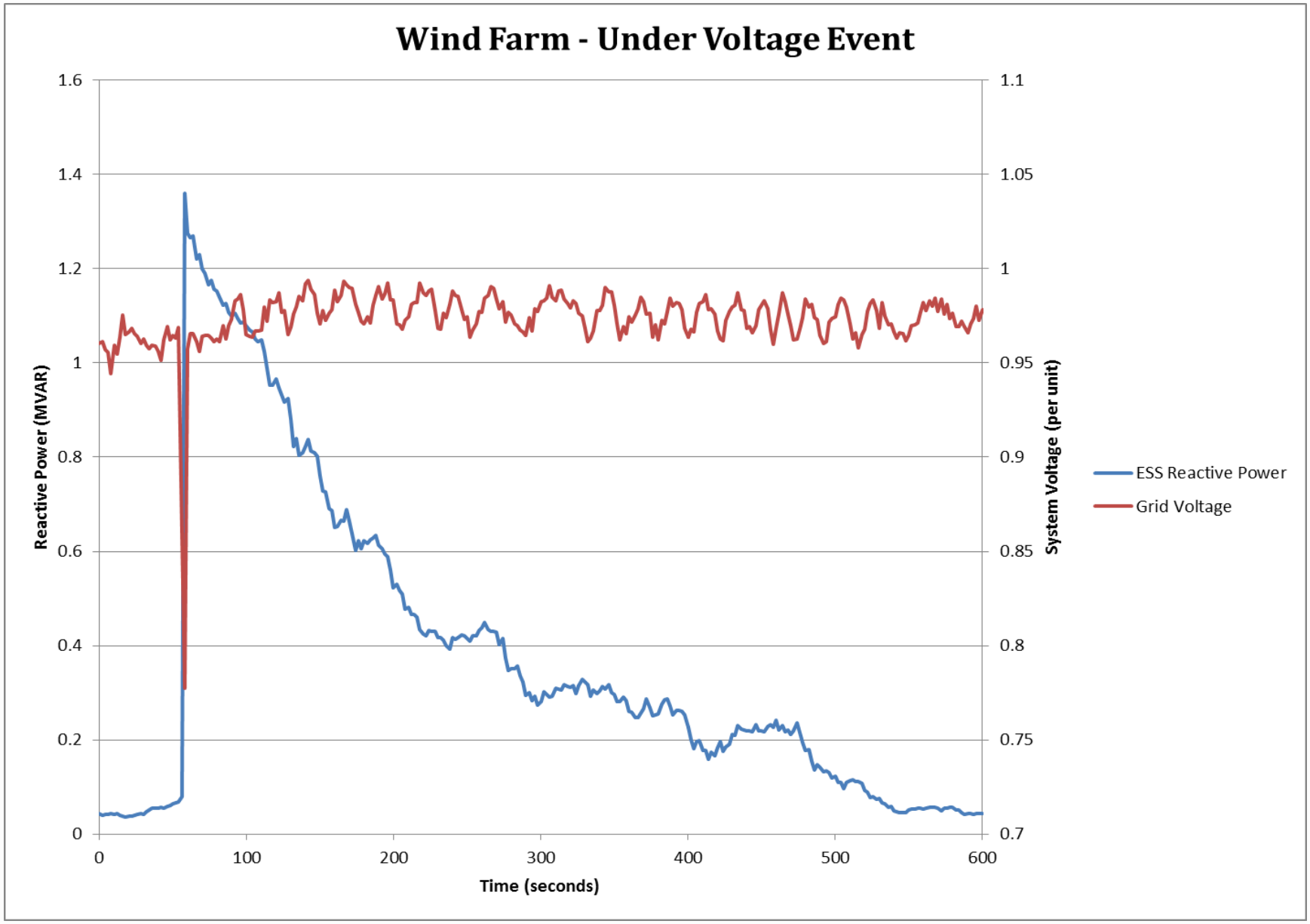
Grid Undervoltage Event Charts



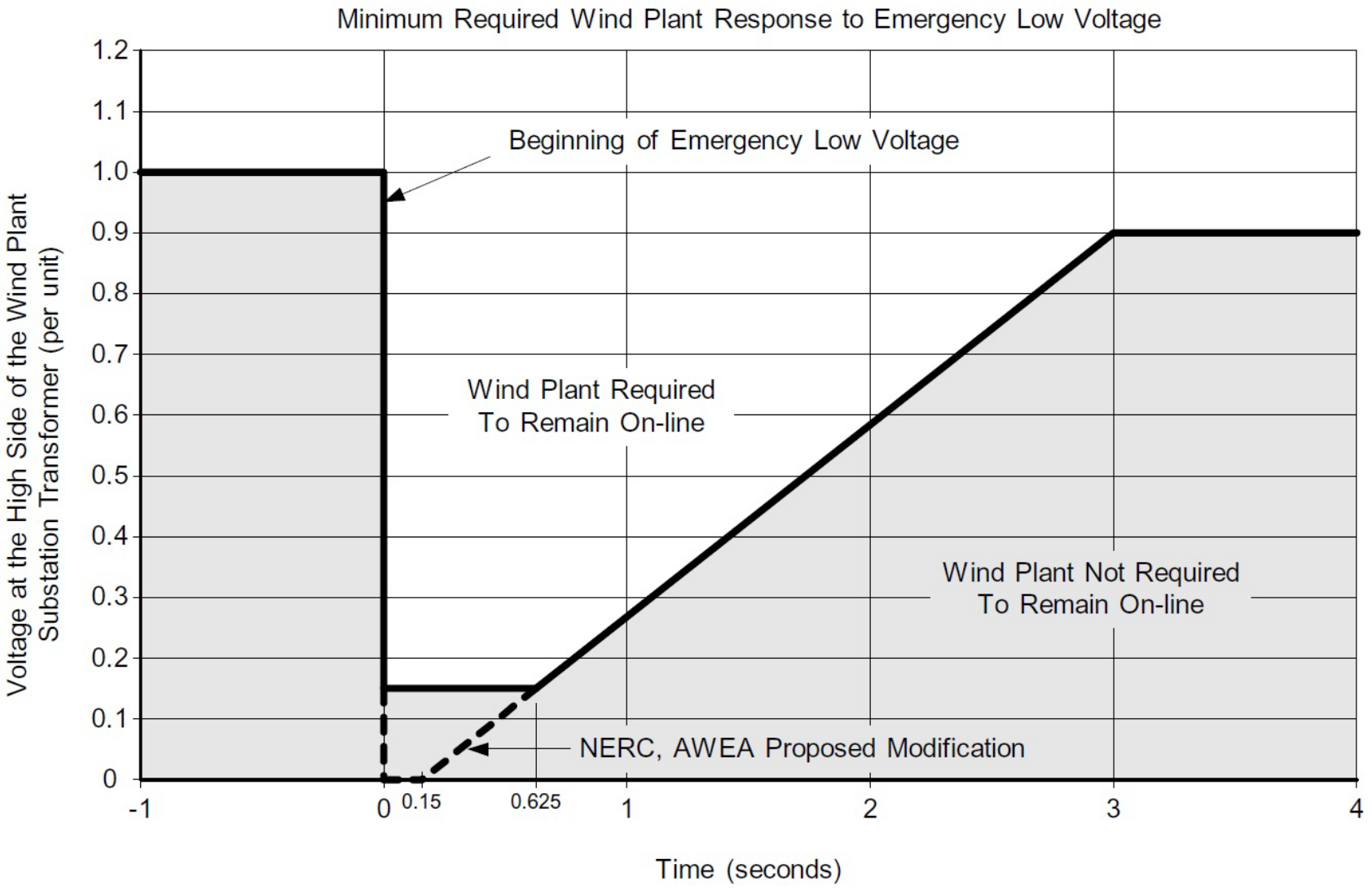
Grid Undervoltage Event Charts cont.



Considerations

- Different Wind Turbine Generator topologies have different ride through capabilities and challenges
  - Not the issue in this case
- Application of UL 1741 and IEEE 1547 ride through requirements
  - FERC 661a - 2005
- Maximize utilization of power conversion system capabilities
  - Penetration of power electronic based generation sources will increase

Voltage Ride Through Reference (FERC 661)



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