

## **Webinar Content Descriptions**

- 1.** CIP, MOD, NUC, PER & TPL Concepts & Standards Webinar
- 2.** COM (Communication), FAC (Facility) & INT (Interchange) Concepts & Standards
- 3.** Dynamics Of Disturbances #1
- 4.** Dynamics Of Disturbances #2
- 5.** Dynamics Of Disturbances #3
- 6.** EOP (Emergency Operations) Concepts & Standards
- 7.** Extreme Weather Events & The Industry's Response Webinar Topics
- 8.** Frequency Control Concepts & Standards
- 9.** Generator Theory, Design, Operation & Protection
- 10.** IBR (Inverter Based Resource) Theory, Operation & Events
- 11.** IRO (Interconnected Reliability Operations) Concepts & Standards
- 12.** NERC Certification Test Preparation
- 13.** Power System Fundamentals
- 14.** Power System Stability
- 15.** Power Transformer Theory, Operation & Protection
- 16.** PRC (Protection & Control) Concepts & Standards
- 17.** PSR (Power System Restoration) Theory & Practice
- 18.** TOP (Transmission Operations) Concepts & Standards
- 19.** Transmission Line Protection
- 20.** Voltage Control Concepts & Standards

Click On The Webinar Title To See Details Of That Webinar.

# **1. CIP (Critical Infrastructure Protection), MOD (Modeling, Data & Analysis), NUC (Nuclear), PER (Personnel Performance, Training & Qualifications) & TPL (Transmission Planning) Concepts & Standards (10 CEH /10 Standards)**

## **Course Description: Describe & Illustrate The Concepts & Content Within The CIP (Critical Infrastructure Protection), MOD (Modeling, Data & Analysis), NUC (Nuclear), PER (Personnel Performance, Training & Qualifications) & TPL (Transmission Planning) Categories Of NERC's Reliability Standards**

Learning Objective 1: Briefly Describe & Illustrate The Concepts & Content Within NERC's CIP Series Of Reliability Standards (3 CEH/3 Standards)

- Topics Addressed Include A Description Of The Cyber Threat To Power Systems & A Review Of The Steps In The Industry's Response To That Threat Then A Brief Description Of The Purpose & Content Of Each Of The CIP Series Of Standards Including: CIP-002-5.1a: Cyber Security – BES Cyber System Categorization, CIP-003-8: Cyber Security – Security Management Controls, CIP-004-7: Cyber Security – Personnel & Training, CIP-005-7: Cyber Security – Electronic Security Perimeter(s), CIP-006-6: Physical Security Of Cyber Systems, CIP-007-6: Cyber Security – System Security Management, CIP-008-6: Cyber Security – Incident Reporting & Response Planning, CIP-009-6: Cyber Security – Recovery Plans For BES Cyber Systems, CIP-010-4: Cyber Security – Configuration Change Management & Vulnerability Assessments, CIP-011-3: Cyber Security – Information Protection, CIP-012-1: Cyber Security – Communications Between Control Centers, CIP-013-2: Cyber Security – Supply Chain Risk Management & CIP-014-3: Physical Security

Learning Objective 2: Briefly Describe & Illustrate The Concepts & Content Within NERC's MOD Series Of Reliability Standards (3 CEH/3 Standards)

- Topics Addressed Include The Concepts Of Total & Available Transfer Capability, The Need For Accurate Computer Models Including Generator Capability Curves & The Importance Of Having Accurate Computer Models To Study The Performance Of IBRs Such As Photo-Voltaic & Wind-Turbine Generators Then A Brief Description Of The Purpose & Content Of Each Of The MOD Series Of Standards Including MOD-001-1a: Available Transmission System Capability, MOD-004-1: Capacity Benefit Margin, MOD-008-1: Transmission Reliability Margin, MOD-025-2: Verification & Data Reporting Of Generator Real & Reactive Power Capability & Synchronous Condenser Reactive Power Capability, MOD-026-1: Verification Of Models & Data For Generator Excitation Control System Or Plant Volt/Var Control Functions, MOD-027-1; Verification Of Models & Data For Turbine/Governor & Load Control Or Active Power/Frequency Control Functions, MOD-028-2: Area Interchange Methodology MOD-029-2a: Rated Path System Methodology,

MOD-030-3: Flowgate Methodology, MOD-031-3: Demand & Energy Data,  
MOD-032-1: Data For Power System Modeling & Analysis & MOD-033-2:  
Steady-State & Dynamic Model Validation

Learning Objective 3: Briefly Describe & Illustrate The Concepts & Content Within NERC's  
NUC Series Of Reliability Standards (1 CEH / 1 Standards)

- Topics Addressed Include A Description Of The Coordination Needs Between A Nuclear Power Plant & Its Transmission Entities Then A Description Of The Content Of NUC-001-4: Nuclear Plant Interface Coordination

Learning Objective 4: Briefly Describe & Illustrate The Concepts & Content Within NERC's  
PER Series Of Reliability Standards (0 CEH / 0 Standards)

- Topics Addressed Include An Explanation Of The Need To Have Qualified Personal Operating The Generation & Transmission System Then A Brief Description Of The Content Of PER-003-2: Operating Personnel Credentials, PER-005-2: Operations Personnel Training & PER-006-1: Specific Training For Personnel

Learning Objective 5: Briefly Describe & Illustrate The Concepts & Content Within NERC's  
TPL Series Of Reliability Standards (3 CEH/3 Standards)

- Topics Addressed Include The Concepts Of The Single Most Severe Transmission Contingency, Descriptions Of The Seven Categories Of System Conditions (P0 - P7), The Differences Between Steady-State & Dynamic Simulations, Brief Description Of Angle & Voltage Stability, Explanation Of The GMD Concept, The Need For Geomagnetic Disturbance Planning Then A Brief Description Of The Content Of TPL-001-5.1: Transmission System Planning Performance Requirements & TPL-007-4: Transmission System Planned Performance For GMD Events

## **2. COM (Communication), FAC (Facility) & INT (Interchange) Concepts & Standards Webinar Topics (10 CEH / 10 Standards)**

**Learning Objective: Describe & Illustrate The Concepts & Content Within The COM (Communications), FAC (Facilities) & INT (Interchange) Categories Of NERC's Reliability Standards**

- Describe & Illustrate The Concepts & Content Within NERC's Reliability Standards COM-001-3: Communications & COM-002-4: Operating Personnel Communications Protocols
  - Topics Addressed Include A Description Of The Entities Involved (RC, BA, TOP, GO & DP) & Their Duties In The Interpersonal Communications Process; Concepts Of Interpersonal Communications & Alternative Interpersonal Communications; Concept Of An Operating Instruction; Concept Of Three-Way Communications & Descriptions Of The Content Of The Requirements In The COM-001-3 & COM-002-4 Standards
- Describe & Illustrate The Concepts & Content Within NERC's Reliability Standards FAC-001-4, FAC-002-4, FAC-003-5, FAC-008-5, FAC-011-4 & FAC-014-3
  - Topics Addressed Include A Description Of The Entities Involved (RC, PA, TP, TO, GO & DP) & Their Duties In The Facilities Standards; An Explanation Of The Need For Facility Interconnection Requirements; Description Of How Facility Interconnection Requirements Are Applied To Proposed Facilities; The Need For Vegetation Management Programs; Concept Of MVCD; Concept & Development Of Facility Ratings; Concepts Of SOL, IROL & TV; Application Of SOL/IROL Concepts In Planning & Operating Environments & Descriptions Of The Requirements In The FAC-001-4, FAC-002-4, FAC-003-5, FAC-008-5, FAC-011-4 & FAC-014-3
- Describe & Illustrate The Concepts & Content Within NERC's Reliability Standard INT-006-5: Evaluation of Interchange Transactions & INT-009-3: Implementation of Interchange
  - Topics Addressed Include A Description Of The Entities Involved (BA, TSP, PSE & LSE) & Their Duties In The Interchange Process; Concepts Of Arrange, Assess, Confirm & Implement; Concepts Of Ramp, POR /POD, IOS & E-Tag; Concept Of Dynamic Transfer & Descriptions Of The Content Of The Requirements In The INT-006-5 & INT-009-3 Standards

### **3. Dynamics Of Disturbances #1 Webinar Topics (10 CEH / 3 Standards)**

**Course Description: Using IEEE, FERC, NERC, Regional Entity & Involved Company Disturbance Reports Step Through & Describe The Sequence Of Events During Actual Power System Disturbance Events.**

- Step Through & Describe The Sequence Of Events During The 11/9/1965 Disturbance Event In The Northeastern Portion Of The Eastern Interconnection. (3/0)
  - Description Of The Event Focuses On How The Tools The Industry Has Available Today (Such As RTCA, RSGs, UFLS, Loadability Standards & PSR Procedures Including Designated BSRs) Were Not Widely Available In 1965 & The Consequences Of That Lack Of Tools In A Heavily Stressed System. The Operation Of Z3 Impedance Relays Leading To An Impedance Cascade Is Also Explained & Illustrated.
- Step Through & Describe The Sequence Of Events During The 8/14/2003 Disturbance Event In The Eastern Interconnection. (4/2)
  - Topics Addressed Include The Importance Of Accurate System Operator Communications As Required By COM-002-4, The Need For Vegetation Management Rules As Required By FAC-003-4: "Transmission Vegetation Management", The Importance Of Situational Awareness & The Need For TOPs & RCs To Have Operational Analyses & Real Time Assessment Tools As Mandated By IRO-008-2, The Need For Transmission Loadability Rules As Required By PRC-023-4 & The Mechanics Of An Impedance Cascade, The Need For Each Transmission Operator To Maintain Adequate Dynamic Reactive Reserves As Mandated By VAR-001-5, The Relationship Between Voltage Control & Angle Stability & How This Disturbance Moved The Electric Industry From The Then Existing Operating Policies To Today's Mandatory Reliability Standards.
- Step Through & Describe The Sequence Of Events During The 7/02/1996 & 8/10/1996 Disturbance Events In The Western Interconnection. (3/1)
  - Topics Addressed Include The Importance Of Dynamic Reactive Reserves As Stated In VAR-001-5: "Voltage & Reactive Control", The Need For Accurate Generator Capability Curves In As Stated In MOD-025-2: "Verification & Data Reporting Of Generator Real & Reactive Power Capability & Synchronous Condenser Reactive Power Capability", The Mechanics Behind The Formation Of Islands During Disturbances & Illustrate Oscillatory Instability Using Actual Plots Of The 8/10/1996 Transmission Line Flows.

#### **4. Dynamics Of Disturbances #2 Webinar Topics (10 CEH/5 Standards)**

**Course Description: Using IEEE, FERC, NERC, Regional Entity & Involved Company Disturbance Reports Step Through & Describe The Sequence Of Events During Actual Power System Disturbance Events.**

- Step Through & Describe The Sequence Of Events During The 2/14/2008 Disturbance Event @ The Huntington Generator In The Western Interconnection. (2/1)
  - Topics Addressed Include The Importance Of Recovering ACE Following A Generation Loss As Required By BAL-001-2, The Importance Of Recovering Contingency Reserve As Required By BAL-002-3, The Consequences Of Single Points Of Failure In Protection Systems & The Role Of An RC During A Major Disturbance As Stated In IRO-001-4.
- Step Through & Describe The Sequence Of Events During The 11/09/2016 California ISO Event In The Western Interconnection. (1/1)
  - Topics Addressed Include How Incorrect Generation Dispatch Orders Resulted In The BA Developing An ACE Of -3,245 MW & Frequency Dropping To 59.83 HZ. Examine This Event From A BAL-001-2, BAL-002-3, IRO-001-4 & IRO-006-5 Perspective.
- Step Through & Describe The Sequence Of Events During The 3/13/1989 Disturbance Event In The Quebec Interconnection. (4/2)
  - Topics Addressed Include The Concepts Of CMEs, GICs & ESPs, The Purpose & Usage Of The K-Index & G-Scale, How The Loss Of Key Voltage Control Equipment Led To The Collapse Of The Quebec Power System, How The Salem Nuclear Unit's GSU Was Damaged Shortly After The Event By GIC Flow, The Content Of EOP-010-1: "Geomagnetic Disturbance Operations", With Respect To TOP & RC GMD Monitoring Responsibilities & Examine TPL-007-4: "Transmission System Planned Performance for Geomagnetic Disturbance Events", With Respect To System Planners GMD Preparedness.
- Step Through & Describe The Sequence Of Events During The 6/14/2004 Disturbance Event In The Arizona Area Of The Western Interconnection. (3/1)
  - Topics Addressed Include The Need To Maintain Protective Relay Components As Required By PRC-005-6: "Protection System, Automatic Reclosing, & Sudden Pressure Relaying Maintenance", Consequences Of Incorrect Assumptions Of CB Position (Open Versus Closed), The Dangers Associated With Voltage Phase Angle Growth During Extended Faults, The Importance Of Recovering From An IROL Exceedance Within The  $T_V$  Value As Described In IRO-009-2: "RC Actions To Operate Within IROLs" & TOP-001-5: "Transmission Operations" As Related To The Overload That Results On WECC's Path #66.

## **5. Dynamics Of Disturbances #3 Webinar Topics (10 CEH/4 Standards)**

**Course Description: Using IEEE, FERC, NERC, Regional Entity & Involved Company Disturbance Reports Step Through & Describe The Sequence Of Events During Actual Power System Disturbance Events.**

- Step Through & Describe The Sequence Of Events During The 6/25/1998 Disturbance Event In The MAPP (Now MRO) Area Of The Eastern Interconnection. (2/1)
  - Topics Addressed Include The Importance Of Recovering Rapidly From An IROL Exceedance As Stated In IRO-009-2: “RC Actions To Operate Within IROLs” & TOP-001-5: “Transmission Operations”, The Impact Of The Unexpected Operation Of Reclosing Relays During Disturbance Events & The Importance Of Coordinating OOS Tripping & Blocking Relays.
- Step Through & Describe The Sequence Of Events During The 2/26/2008 Disturbance Event In The Florida Area Of The Eastern Interconnection. (2/1)
  - Topics Addressed Include The Consequences Of Protection Engineers & System Operators Intentionally Disabling Primary & Backup Protection, The Impact Of Location Related Differences In Transient Frequency, The Impact Of Frequency Oscillations, The Operation Of Florida’s UFLS Scheme In The Context Of Standard PRC-006-5: “Automatic UFLS” & The Need For Properly Trained TOP & RC System Operators As Stated In PER-003-2: “Operating Personnel Credentials”.
- Step Through & Describe The Sequence Of Events During The 9/8/2011 Disturbance Event In The Southwest Corner Of The Western Interconnection. (4/2)
  - Topics Addressed Include The Importance Of Testing & Understanding The Operation Of RAS As Stated In PRC-012-2: “RAS”, The Need For RCs & Their Responsibility To Act To Maintain Reliability As Required By IRO-001-4: “RC - Responsibilities”, The Cause Of Large Voltage Phase Angles Across Open CBs, The Consequences Of Skipping Steps In Switching Orders & The Purpose Of PRC-023-4: “Transmission Relay Loadability” From A Transformer Loadability Perspective.
- Summarize The Sequence Of Events During Recent Disturbances That Involved Inverter Based Resources (IBRs). (2/1)
  - Topics Addressed Include Brief Descriptions Of Disturbance Events That Involved Photo-Voltaic, Wind Turbine Generators & Battery Energy Storage Systems (BESS) In The Past 5 Years.

## **6. EOP (Emergency Operations) Standards & Concepts Webinar Topics (10 CEH/10 Standards)**

**Learning Objective: Describe & Illustrate The Content Of & Technical Concepts Within NERC 's Reliability Standards EOP-004-4, EOP-005-3, EOP-006-3, EOP-008-2, EOP-010-1, EOP-011-2, EOP-011-3, EOP-011-4, EOP-012-1 & EOP-012-2**

- Describe & Illustrate The Content & Concepts Within NERC's Reliability Standard EOP-004-4: Event Reporting
  - Topics Addressed Include The Need For Event Reporting, A Brief Description Of NERC's Event Analysis Process & A Description Of The Content Of The Requirements Within EOP-004-4
- Describe & Illustrate The Content & Concepts Within NERC's Reliability Standard EOP-005-3: System Restoration From Blackstart Resources
  - Topics Addressed Include The Concept Of A Black Start Resource, The Concept Of A Cranking Path, The Theory & Methods Of Synchronizing, The Purpose Of A TOP's Restoration Plan & A Description Of The Content Of The Requirements Within EOP-005-3
- Describe & Illustrate The Content & Concepts Within NERC's Reliability Standard EOP-006-3: System Restoration Coordination
  - Topics Addressed Include The Purpose Of An RC's Restoration Plan & A Description Of The Content Of The Requirements Within EOP-006-3
- Describe & Illustrate The Content & Content Within NERC's Reliability Standard EOP-008-2: Loss Of Control Center Functionality
  - Topics Addressed Include The Need For Backup Control Center Plans For BAs, TOPs & RCs & A Description Of The Content Of The Requirements Within EOP-008-2
- Describe & Illustrate The Content & Concepts Within NERC 'S Reliability Standard EOP-010-1: Geomagnetic Disturbance Operations
  - Topics Addressed Include A Description & Illustration Of The GMD Concept, Descriptions Of TOP & RC Roles With Respect To GMDs & A Description Of The Content Of The Requirements Within EOP-010-1
- Describe & Illustrate The Content & Concepts Within NERC's Reliability Standard EOP-011-2: Emergency Preparedness & Operations
  - Topics Addressed Include The Purpose & Usage Of Generation Redispatch, The Purpose & Usage Of Transmission Reconfiguration, Usage & Coordination Of Manual & Automatic Load Shedding, Difference Between Capacity & Energy Emergencies, EEA Purpose & Levels & A Description Of The Content Of The Requirements Within EOP-011-2 & Descriptions Of Changes In The New EOP-011-3 & EOP-011-4
- Describe & Illustrate The Content & Concepts Within NERC's Reliability Standard EOP-012-1: Extreme Cold Weather Preparedness & Operations
  - Topics Addressed Include An Explanation Of The Need For A Standard To Require



Cold Weather Preparation Of BES Generators & A Description Of The Content Of  
The Requirements Within EOP-012-1 & The New EOP-012-2

## **7. Extreme Weather Events & The Industry's Response Webinar Topics (15 CEH / 5 Standards)**

### **Learning Objective: A Review Of The Lessons Learned From & The Regulatory Response To Extreme Weather Events In The Last Five Years With The NERC Power Systems**

1. Step Through & Describe The Sequence Of Events Within The ERCOT, SPP & MISO Systems During The February 2021 Winter Storm Uri Extreme Cold Weather Event & The Lessons Learned From This Event
2. Step Through & Describe The Sequence Of Events Within The Eastern Interconnection During The December 2022 Winter Storm Elliott Extreme Weather Event & The Lessons Learned From This Event
3. Step Through & Describe The Sequence Of Events Within The California ISO During The August 2020 Extreme Heat Wave Event & The Lessons Learned From This Event

## **8. Frequency Control Concepts & Standards Webinar Topics (10 CEH/10 Standards)**

### **Learning Objective: Describe & Illustrate Frequency Control Theory & Describe The Content Of The BAL Series Of Reliability Standards**

- Describe & Illustrate The Frequency Control Theory Associated With Reliability Standard BAL-001-2 & Evaluate This Standards Impact On System Operations
  - Topics Addressed Include A Review Of Generation Types Used In The US, The Energy Balance Concept, The Concept Of Inertia, The Load-Damping Concept, Acceptable Frequency Range, Concept & Types Of Operating Reserves, Governor Control Process Including Droop & Deadband, Problems With Step-Response In Governor Deadband, The AGC Process, Constant Frequency, Constant Interchange & Tie-Line Bias AGC Modes, Concepts & Illustration Of CPS-1 & BAAL, The Difference Between Supplemental & Overlap Regulation Services & A Description & Explanation Of The Requirements In BAL-001-2
- Describe & Illustrate The Frequency Control Theory Associated With Reliability Standard BAL-002-3 & Evaluate This Standards Impact On System Operations
  - Topics Addressed Include A Description Of DCS Terminology (Including Most Severe Single Contingency, Balancing Contingency Event, Reportable Balancing Contingency Event, The Application Of The DCS, A Review Of The Contingency Reserve Definition, The Usage & Restoration Of Contingency Reserve & A Description & Explanation Of Requirements In BAL-002-3
- Describe & Illustrate The Frequency Control Theory Associated With Reliability Standard BAL-003-2 & Evaluate This Standards Impact On System Operations
  - Topics Addressed Include A Description Of The Frequency Response Process, The Concept Of An FRSG, The Frequency Bias Concept, The Impact Of Load Damping, Concepts Of FRM, IFRO & FRO, Description Of The Overlap & Supplemental Regulation Services & A Description & Explanation Of The Requirements In BAL-003-2
- Describe & Illustrate The Frequency Control Theory Associated With Reliability Standard BAL-005-1 & Evaluate This Standards Impact On System Operations
  - Topics Addressed Include A Description & Demonstration Of The Usage Of The Tie-Line Bias ACE Equation, The Usage Of HVDC With AGC, The Concepts Of Host BA, Dynamic Schedules & Pseudo-Ties & A Description & Explanation Of The Requirements In BAL-005-1
- Describe & Illustrate The Concepts Of Inadvertent Energy Accounting & Time Error Control & Examine The Details Of The Decay In Frequency Following A Loss Of Generation
  - Topics Addressed Include A Description Of The Inadvertent Interchange Calculation & Payback Process, The Difference Between Primary & Secondary Inadvertent, Basic Inadvertent Accounting Principles, A Description Of The Time Error Control Process & The Roles Of RCs & BAs, A Description Of Automatic

Time Error Control (ATEC) As Used In The WECC, A Description & Explanation Of The Requirements In BAI-004-WECC-3 & A Description Of The Frequency Event Process Including Its Four Different Stages & Four Different Periods.

## **9. Generator Theory, Design & Operation & Protection Webinar Topics (10 CEH / 7 Standards)**

### **Learning Objective: Describe & Illustrate The Theory, Design, Operation & Protection Of The Various Types Of Generators Used Within The NERC Power Systems**

- Describe The Theory, Design & Operation Of Steam Turbine Generators (Including Coal & Nuclear Prime Movers), Hydro Generators (Including Pumped Storage), Photo-Voltaic Generators & Wind-Turbine Generators
  - Topics Addressed Include The Concept Of Electromagnetic Induction, The Components Of A Rotating Generator, The Design & Usage Of Excitation & Governor Control Systems, Describe MOD-025-2 Content With Respect To Its Requirement That Generator Owners Test & Record Their BES Generator Reactive Capability, The Concept of Inertia & The Risks Of Reduced Inertia Levels, Steam-Turbine Design & Operation Issues, Combustion-Turbine Design & Operation Issues, Hydroelectric-Turbine Design & Operation Issues, Describe The Generator Synchronizing Process, The Design & Operation Of The Inverters Used By IBRs Emphasizing Their Ability To Respond To Voltage & Frequency Deviations, P-V Plant Design & Operation Issues, P-V Plant Compliance Issues With PRC-024-3 With Respect To Their Incorrect Tripping When Power System Voltage & Frequency Deviations Occur, Wind-Turbine Design & Operation Issues, Describe The Consequences Of The Variable Nature Of The Fuel Supply For Wind & PV Generators & The Characteristics Of The Generators Used As BSRs By TOPs As Required By EOP-005-3
- Describe & Illustrate The Typical Protection Used On Generators
  - Topics Addressed Include How Generators Are Protected For Stator Phase & Ground Faults, The Purpose & Application Of Imbalance Protection, The Need For Generator Back-Up Protection For Un-Cleared Transmission System Faults, The Need For Loadability Requirements To Limit False Tripping As Mandated By PRC-025-2, Issues With The Application Of Excitation Limiters & The Need To Coordinate Voltage Based Generator Protection & Controls As Described In PRC-019-2, The Need For Volts-Per-Hertz Protection, The Need For & Methods Of Anti-Motoring Protection, The Need & Coordination Issues With Underfrequency Protection, Future Requirements For Extreme Cold- Weather Preparedness & Operations As Stated in EOP-012-1 As It Relates To Recent Generator Tripping During Extreme Cold Weather, Need For & Risks With Applying Out-Of-Step Protection, The Need For & Methods Of Field- Ground- Protection, Describe IBR Protection Methods Including Issues With IBR Fault Current Contribution & The Need To Coordinate The Overall Protection Of Generators To Ensure The Right Relays Operate @ The Proper Time As Mandated By The Protection Coordination Standard For Generators PRC-027-1

## **10. IBR (Inverter Based Resource) Theory, Operation & Events Webinar Topics (15 CEH / 6 Standards)**

**Learning Objective: Describe & Illustrate The Theory, Operation & Reliability Impacts Of Inverter Based Resources (IBRs) & Describe & Illustrate Disturbance Events That Have Involved IBRs & The Lessons Learned From These Events**

- Briefly Describe & Illustrate The Theory & Operation Of The Power Electronics Used In Inverters Including Thyristors & Insulated-Gate Bipolar Transistors (IGBTs)
  - Concepts Of Semiconductor, P & N Type Region, Thyristor & IGBT
- Describe & Illustrate The Theory & Operation Of The Inverters Used To Connect IBRs To The Power System
  - Concepts Of Converter, Rectifier, Inverter, Pulse-Width Modulation (PWM) & Voltage Sourced Converters (VSC)
  - Brief Description Of VSCs Used For MW & MVAR Control
  - Examples of IBRs
  - Describe How IBRs Are Synchronized
  - Concepts Of Grid-Following & Grid-Forming Inverters
  - Description Of PRC-027-1 Requirements From The Perspective Of IBRs As Fault Current Sources
- Describe & Illustrate The Usage Of IBRs As MW & MVAR Flow Control Devices Including SVC, STATCOM, D-VAR & SSSC
  - Theory & Operation Of SVC
  - Theory & Operation Of STATCOM
  - Theory & Operation Of D-VAR
  - Theory & Operation Of SSSC
  - Description Of VAR-001-5 & VAR-002-4.1 Content From An IBR Voltage Control Perspective
  - Description Of PRC-024-3 Content From An IBR Voltage Control Perspective
- Describe & Illustrate The Concept Of Inertia & The Cause & Impact Of Reduced Power System Inertia Levels
  - Describe & illustrate The Concept Of Inertia
  - Compare The Frequency Response Of Power Systems With Different Inertia Levels
  - Estimate The Inertial Energy In Different Types Of Generators
  - Describe The Methods Used To Address Declining Power System Inertia Levels
  - Description Of PRC-024-3 Content From An IBR Frequency Control Perspective
- Describe & Illustrate The Theory & Operations Of WTGs & Describe & Illustrate Disturbance Events Involving WTGs
  - Describe & Illustrate The Theory & Operation of WTGs
  - Describe WTG Frequency Response Capability
  - Illustrate WTG Capacity In The USA

- Describe & Illustrate Actual WTG Facilities
- Briefly Describe & Illustrate The February 2021 Artic Event Impact In ERCOT, SPP & MISO Emphasizing WTG Performance
- Briefly Describe & Illustrate The March 22, 2022, Texas Panhandle Wind Event
- Explanation Of The Need To Improve Resource Planning
- Review The Content Of NERC's Reliability Vignette: Future Wind Planning Informed By Current Operating Experience, September 2022
- Describe & Illustrate The Theory & Operation Of Battery Energy Storage Systems (BESS) & Describe & Illustrate Disturbance Events Involving BESS
  - Describe & Illustrate The Theory & Operation Of BESS
  - Describe & Illustrate The Types & Operation Of BESS
  - Describe & Illustrate Disturbance Events Involving BESS Including:
  - Summary Of Recent BESS Disturbance Events In the USA
  - Arizona Public Service April 2019 BESS Event
  - Briefly Describe The Theory & Operation Of Pumped-Storage Hydro
- Describe & Illustrate The Theory & Operation Of Photo-Voltaic (PV) Plants & Describe & Illustrate Disturbance Events Involving PV Plants
  - Concept Of The Photo-Voltaic Effect & PV Cell Design & Operation
  - Illustrate PV Plant Capacity In The USA
  - Describe The Components Of PV Plants
  - Describe The Operating Modes Of PV Plants
  - Describe & Illustrate Actual PV Facilities
  - Using NERC Event Reports, Briefly Describe & Illustrate The Following PV Related Events
    - Blue Cut Fire Event – 8/16/2016
    - Canyon 2 Fire Event – 10/9/2017
    - Angeles Forest Event – 4/20/2018
    - Palmdale Roost Event – 5/11/2018
    - San Fernando Event – July 7, 2020
    - Odessa Events - May 9, 2021 & 6/26/2021
    - Victorville Event – 6/24/2021
    - Tumbleweed Event – 7/4/2021
    - Windhub Event – 7/28/2021
    - Lytle Creek Fire Event – 8/24/2021

## **11. IRO (Interconnected Reliability Operations) Concepts & Standards Webinar Topics (10 CEH / 10 Standards)**

**Learning Objective: State The Purpose Of The IRO Series Of NERC Reliability Standards & Describe & Illustrate The Concepts & Content Within Each Of The Nine Standards In The IRO Series**

- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-001-4: RC Responsibilities
  - Topics Addressed Include A Description Of Roles Performed By The RC, TOP, TO, BA, GOP, GO, DP, PC & TP; RC's Need For Wide-Area View; Concepts Of SOL & IROL; Difference Between BES & BPS; Concept & Usage Of Operating Instructions & A Description Of The Requirements Within IRO-001-4
- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-002-7: RC Monitoring & Analysis
  - Topics Addressed Include The Need For Sharing Operational Data Between Operating Entities; Concept Of RAS; Concept Of Real-Time Assessment & A Description Of The Requirements Within IRO-002-7
- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-006-5: RC TLR
  - Topics Addressed Include The Concept & Usage Of TLR Procedures; Descriptions Of Eastern Interconnection's TLR & WECC's USF & A Description Of The Requirements Within IRO-006-5
- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-008-2: RC Operational Analysis & Real-Time Assessments
  - Topics Addressed Include The Concepts Of An Operating Plan, Operational Analysis & Real- Time Assessment; Description Of The RTCA Process & A Description Of The Content Of the Requirements Within IRO-008-2
- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-009-2: RC Actions To Operate Within IROLs
  - Topics Addressed Include A Description Of The Content Of The Requirements Within IRO-009-2
- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-010-3: RC Data Specification & Collection
  - Topics Addressed Include An Explanation Of The Need For An RC Data Specification; A Description Of The Requirements Within IRO-010-3 & The Need For Addressing Extreme Cold Weather Conditions In Reliability Standards Such As The New IRO-010-4
- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-014-3: Coordination Among RCs
  - Topics Addressed Include The Importance Of Coordinating Operations Between RCs; NERC's Definitions of Emergency & Adverse Reliability Impact & A Description Of The Requirements Within IRO- 014-3



- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-017-1: Outage Coordination
  - Topics Addressed include The Need For & Description Of The Outage Coordination Process For Generation & Transmission & A Description Of The Requirements Within IRO-017-1
- Describe & Illustrate Concepts & Content Within NERC's Reliability Standard IRO-018-1(i): RC Real-Time Reliability Monitoring & Analysis
  - Topics Addressed Include The Need For Real-Time Monitoring & Analysis; Concepts Of Operating Process & Operating Procedure; Concept Of Real-Time Data Quality; Need For An Alarm Process Monitor To Detect Failure Of Real-Time Monitoring Capability & A Description Of The Requirements Within IRO-018- 1(i)

## **12. NERC Certification Test Preparation Webinar (20 CEH / 20 Standards)\***

This Four-Day, Five-Hour Per Day Webinar Is Designed To Prepare Students For A NERC Certification Test. This Webinar Assumes Students Have An Understanding Of Basic Power System Operations Including Frequency Control, Voltage Control & Transmission Operations. The Webinar Also Assumes Students Have A Basic Understanding Of The Operations Related Content Of The NERC Reliability Standards. Mike Terbrueggen Will Pose Multiple-Choice Questions To The Students & Then Answer Any Questions Students May Have On The Technical Aspects Of The Question. Cost Of The Webinar Is \$1,000 Per-Student & The General Content Of Each Of The Four Days Of The Webinar Is Described Below.

Various NERC Test Preparation Materials Will Be Provided To The Students Prior & During The Webinar Including, But Not Limited To:

- Test Reference Materials From NERC
- Test Reference Materials From FERC
- Test Reference Materials From IEEE
- O-T-S Self-Study Notes On The Content Of The NERC Reliability Standards
- O-T-S Power System Rules-Of-Thumb Summary Document
- O-T-S NERC Test Preparation Tips Document
- O-T-S Important Power System Formulas Summary Document
  
- Day 1 Content
  - Question & Answer Session Related To Topical Areas Addressed In The BAL & COM Series Of Standards
- Day 2 Content
  - Question & Answer Session Related To Topical Areas Addressed In The CIP, EOP, FAC, MOD & NUC Series Of Standards
- Day 3 Content
  - Question & Answer Session Related To Topical Areas Addressed In The INT, IRO & PRC Series Of Standards
- Day 4 Content
  - Question & Answer Session Related To Topical Areas Addressed In The TOP, TPL & VAR Series Of Standards

After Each Day Of The Four-Day Webinar Students Will Be Directed To An On-Line Testing Site To Take Practice Tests In A Format Similar To How Actual NERC Certification Tests Are Delivered. Mike Will Be Available To Answer Any Questions Students May Have On These Tests During The Next-Days Webinar Or Via E- Mail Communications.

\*CEH Can Be Awarded For This Webinar. Total CEH Is 20, All Of Which Qualify As Standards CEH.

### **13. Power System Fundamentals Webinar Topics (15 CEH / 0 Standards)**

#### **Learning Objective: An Introduction To The NERC Power System, To DC & AC Theory Concepts & To NERC's Functional Model**

- Describe & Illustrate The Organizational Structure & Components Of The North American Power System
  - Review The Math Concepts Of The Per-Unit System, The Constant Pi & Engineering Notation
  - Using A Simple Diagram Of The Key Components Of The Power System Step Through & Discuss A Typical Power System Arrangement. First Explain The Generator Role, Then The GSU Transformer, Circuit Breaker, Transmission Line, Disconnect Switches, Circuit Switchers, Power Transformers, Sub-Transmission Line, Distribution System & With The Customers
  - Discuss How Load Varies Moment To Moment, Hourly, Daily, & Seasonally. Describe The Load Forecasting Process & The Concepts Of Peak & Off-Peak
  - Discuss How The NERC Power System Is Divided Into Four Interconnections
  - Briefly Discuss The Roles Of Organizations Who Administer The Power System, Including The Roles Of FERC, NERC, Regional Entities & NAESB, The Concepts Of BPS & BES, Describe The Process By Which NERC Reliability Standards Are Developed, & Review Content Areas Of A Typical NERC Reliability Standard
  - Discuss Generation System Components & Their Usage Including The Types Of Generation Used Within NERC, Operation Of Classical Generation Including The Purpose Of Rotor, Stator, Prime Mover, Governor, & Exciter, Inverter-Based Resource (IBR) Concept & Usage, Use Photographs To Describe & Illustrate The Types Of Generation Used In The Power System, & Discuss The Concept & Purpose Of Reliability Must Run (RMR) Generation
  - Discuss Transmission System Components & Their Usage Including The Purpose & Usage Of Transformers, Disconnect Switches, Circuit Breakers, Bus-Work, Shunt Capacitors, Shunt Reactors, Ground Mats, Transmission Lines, Line Conductor, Insulators, Protective Relaying Components, Instrument Transformers, IEEE Device Numbers, Operation Of Differential Relays, The Operation Of Distance Relays & The Purpose Of UVLS & UFLS
- Describe & Illustrate Fundamental Concepts Including DC & AC Theory, Generator Control Systems Including Governor & Excitation Control & Inverter-Based Resources (Wind Turbine, Solar, Battery Etc.) Theory & Operation
  - Discuss Fundamental DC Principles & Concepts. Topics Addressed Include Ohm's Law, Kirchhoff's Law, Power Formulas, Concept Of Energy, Integrated Demand & HVDC Transmission. Discuss Fundamental AC Principles & Concepts. Topics Addressed Include The Theory Of Electromagnetic Induction, AC Sine Wave Terminology, Description Of Inductance, Capacitance & Phase Angle, Natural Capacitance Of Transmission Lines, Transformer 3-Phase Wye & Delta Connections & A Description Of MW, MVar, MVA & The Power Triangle. Discuss Fundamental Principles Of Generator Control Systems. Topics Addressed Include An Illustration Of

- The Synchronizing Process, Illustration Of Basic Governor Control System Operation, Basic Excitation Control System Operation, Concept Of A Reactive Capability Curve & A Description & Illustration Of The Methods Used To Connect Inverter-Based Resources (IBRs) To The Interconnection
- Describe The Job Function Of Each Of The Functional Entities Listed In NERC's Version 5.1 Functional Model & Defined In NERC's Glossary Of Terms
    - The Functional Entities Addressed Include:
      - Generation Owner (GO) & Generation Operator (GOP)
      - Balancing Authority (BA)
      - Transmission Owner (TO), Transmission Operator (TOP) & Transmission Provider (TSP)
      - Reliability Coordinator (RC)
      - Distribution Provider (DP) & Load Serving Entity (LSE)
      - Planning Coordinator (PC), Transmission Planner (TP) & Resource Planner (RP)
      - Market Operator & Purchasing Selling Entity (PSE)
      - Standards Developer, Compliance Enforcement Authority & Reliability Assurer

## **14. Power System Stability Webinar Topics (10 CEH / 5 Standards)**

### **Learning Objective: Describe & Illustrate Power System Stability Concepts Including Angle Stability & Voltage Stability**

- Describe & Illustrate Concepts of MW & MVar Flow & Describe Theory & Operation Of Equipment Used To Control MW Flow
  - Topics Addressed Include Meaning & Value of Voltage Phase Angle Measurement, Utilize Pi Model To Develop Equations For MW & MVar Flow, Demonstrate Usage Of MW & MVar Flow Equations, Explanation Of Cause Of 30° Shift In Wye-Delta Transformer, Description & Illustration Of How Phase Shifting Transformers (PSTs) Used To Control Voltage Phase Angle & MW Flow, Description & Illustration Of How Variable Frequency Transformers (VFTs) Used To Control MW Flow
- Describe & Illustrate Angle Stability & Angle Instability
  - Topics Addressed Include Definitions Of Angle Stability & Angle Instability, Description Of How Short Term Frequency Differences Lead To Angle Instability, Use Phasor Diagram To Illustrate Angle Instability, Describe Three Types Of Angle Stability/ Instability, Description Of How Angle Stability Limits Determined Using Computer Models Described In MOD-032-1 & MOD-033-1, Description Of How Power-Angle Curves Used To Analyze Angle Stability Of Power System, Description Of Usage Of Swing Equation, Description Of Steady-State Stability & Steady-State Instability Using Power Angle Curves, Description Of Transient Stability & Transient Instability Using Power Angle Curves, Description Of Oscillatory Stability & Oscillatory Instability Using Power Angle Curves, Description Of Content Of TPL-001-5.1 Standard As Relates To Stability Based System Operating Limits, Usage Of Braking Resistors, Usage Of Fast Protection, Usage Of Fast Valving Schemes & Usage Of Out-Of-Step (OOS) Blocking & OOS Tripping Protective Relays & Description Of PRC-026-1 As It Relates To OOS Power Swings, Describe Difference Between Natural & Forced Oscillations, Define & Illustrate Inter-Area & Intra-Area & Local & Intra-Plant Modes Of Oscillations, Describe & Illustrate Concept Of Damping Ratio, Describe & Illustrate How PSS Used To Increase System Damping & Describe WECC's PSS Requirements As Stated In VAR-501-WECC-3.1
- Describe & Illustrate Voltage Stability, Voltage Instability & Voltage Collapse
  - Topics Addressed Include Definitions Of Voltage Stability, Voltage Instability & Voltage Collapse, Describe Difference Between Voltage & Angle Stability, Describe & Illustrate three Types Of Voltage Collapse, Description Of Content Of TPL-001-5.1 Standard As Relates To Voltage Stability-Based System Operating Limits, Explain & Demonstrate Construction Of P-V & V-Q Curves, Interpret Shape & Data Presented In Fictional & Actual P-V & V-Q Curves, Step Through Process Of Voltage Collapse Event Using P-V & V-Q Curves, Describe Impact Of Tap Changers & Generator MVar Response On Voltage Collapse Scenarios, Describe Value Of Maintaining Adequate Dynamic Reactive Reserve, Describe

How UVLS Schemes Can Help Prevent Voltage Collapse & Description Of Content  
Of PRC-011-0 & PRC-010-2 Standards As Relates To UVLS Programs

## **15. Power Transformer Theory Operation & Protection Webinar Topics (10 CEH / 5 Standards)**

### **Learning Objective: Describe & Illustrate The Theory, Operation & Methods Of Protecting Power Transformers**

- Learning Objective: Describe & Illustrate Power Transformer Theory Of Operation & Design Principles
  - Topics Addressed Include A Description & Illustration Of Basic Transformer Theory & Construction; Types Of Transformer Windings Including Delta, Wye, Auto, Scott & T-Connection; Difference Between Core-Form & Shell Form Construction; Concepts Of Step-Up & Step-Down; Purpose & Design Of Grounding Transformers; Design & Usage Of Tap Changing Equipment; Explanation Of The Data Typically Found On A Transformer's Nameplate Including Cooling Methods, BIL Rating & Impedance Value; Description Of The Impact Of A GSU Tap Change On The MVAr Output Of A Generator As Stated In VAR-005-1 & A Description Of EOP-010-1 Requirements Related To The Grounded Wye Winding On A Power Transformer
- Describe & Illustrate Common Operating Issues Associated With Power Transformers
  - Topics Addressed Include A Description Of The Concepts Of Over-Excitation & Volts-Per-Hertz; Concept Of Magnetic Core Saturation, Concept Of Magnetizing In-Rush Current, An Explanation Of The Cause Of The Voltage Phase Angle Shift In A Delta-Wye Connected Transformer, The Concept Of A PST & A Description Of The Requirements In PRC-006-5 Related To Volts-Per-Hertz Protection Used On Power Transformers
- Describe & Illustrate Protective Relaying Methods Applied To Power Transformers
  - Topics Addressed Include The Application Of Differential Relays; Application Of Overcurrent Relays For Ground Fault Protection; Application Of Oil Pressure Sensing Devices; Usage Of Overload Protection In Transformers; Describe Typical Overall Protection For A Power Transformer & A Description Of The Requirements In PRC-023-4 That Apply To Power Transformer Protection

## **16. PRC (Protection & Control) Concepts & Standards Webinar Topics (10 CEH / 10 Standards)**

**Learning Objective: State The Purpose Of The PRC Series Of NERC Reliability Standards & Describe & Illustrate The Concepts & Content Within Each Of The Standards In The PRC Series**

- Describe & Illustrate Concepts & Content Within PRC-002-2 & PRC-004-6
  - Topics Addressed Include Descriptions Of Types Of Recording Equipment, Concept Of CB Misoperation, Types Of Protection Backup & A Description Of The Requirements Within PRC-002-2 & PRC-004-6
- Describe & Illustrate Concepts & Content Within PRC-005-1.1b & PRC-005- 6
  - Topics Addressed Include Definitions Of Protection System, Automatic Reclosing, Sudden Pressure & A Description Of The Requirements Within PRC-005-1.1b & PRC-005-6
- Describe & Illustrate Concepts & Content Within PRC-006-5 & PRC-008-0
  - Topics Addressed Include Concept Of Islanding, Concept Of UFLS, Need for Coordination Between UF Tripping Of Generation & UFLS & A Description Of The Requirements Within PRC-006-5 & PRC-008-0
- Describe & Illustrate Concepts & Content Within PRC-010-2, PRC-011-0 & PRC-027-1
  - Topics Addressed Include Concept Of UVLS, Concept Of Protection Coordination & A Description Of The Requirements Within PRC-010-2, PRC-011-0 & PRC-027-1
- Describe & Illustrate Concepts & Content Within PRC-012-2 & PRC-017-1
  - Topics Addressed Include Concept Of RAS, Concept Of Limited Impact RAS, Examples Of RAS & A Description Of The Requirements Within PRC-012-2 & PRC-017-1
- Describe & Illustrate Concepts & Content Within PRC-019-2
  - Topics Addressed Include Concept Of Synchronous Condenser, Description Of An Excitation System, Inverter Role In Voltage Control & A Description Of The Requirements Within PRC-019-2
- Describe & Illustrate Concepts & Content Within PRC-023-4
  - Topics Addressed Include Definition Of Transmission Loadability, Types Of Relays Subject To Transmission Loadability Issues & A Description Of The Requirements Within PRC-023-4
- Describe & Illustrate Concepts & Content Within PRC-024-3
  - Topics Addressed Include Need For Generator Frequency & Voltage Ride-Through Requirements, IBR Ride-Through Issues & A Description Of The Requirements Within PRC-024-3
- Describe & Illustrate Concepts & Content Within PRC-025-2
  - Topics Addressed Include Definition Of Generator Loadability, Types Of Relays Subject To Transmission Loadability Issues & A Description Of The Requirements Within PRC-025-1
- Describe & Illustrate Concepts & Content Within PRC-026-1



- Topics Addressed Include Concept Of Angle Instability, Concept of A Power Swing, Description Of Relays Susceptible To Tripping During Power Swings & A Description Of The Requirements Within PRC-026-1

## **17. Power System Restoration (PSR) Theory & Practice Webinar Topics (15 CEH/8 Standards)**

**Learning Objective: Describe & Illustrate Power System Restoration (PSR) Theory & Practice & Explain & Illustrate The Content Of NERC's Restoration Related Reliability Standards.**

- Using RC & TOP Restoration Documentation, IEEE Restoration Papers, The NERC-FERC-Regional Entity Joint Review Of Restoration & Recovery Plans Reports, NERC's Electric System Restoration Reference Document & Disturbance Event Reports As References, Describe The Theory & Practice Of PSR Including:
  - Restoration Coordination Between RCs, TOPs, BAs, GOPs & DPs
  - Types Of Restoration Conditions & A Brief Summary Of The Causes Of Power System Blackouts
  - Guiding Principles For PSR, General PSR Strategies & Restoration Conditions Assessment
  - Load Issues During PSR Including Load Restoration Priority Concepts, Use Of Technical Load, Load Restoration Limits, The Cold-Load Pickup Concept & The Usage Of Automatic & Manual Load Shedding
  - Initial Approach To The PSR Process Including Choosing Between The Core-Island Versus Backbone Island Approach In The Initial Stages Of PSR & The Parallel Versus Sequential PSR Concepts
  - Concept, Characteristics & Usage Of Black Start Resources (BSRs) & Cranking Paths
  - Switching Issues During PSR Including All-Open Versus Controlled Open Concepts, CB Control Logic Issues & The Need To Establish Substation Station Service ASAP
  - Voltage Control Issues During PSR Including The Need For Reactive Reserves, Issues With Transmission Line Energization, Usage Of Transformer OLTCs Including Circulating MVar, Transformer In-Rush Current, The Ferranti Rise Concept, The Transient Overvoltage (TOV) Concept & Describe PRC-024-3 Requirements With Respect To Generator Ride-Through During Voltage Excursions
  - Frequency Control Issues During PSR Including The Impact Of Low Inertia Conditions, Usage Of Different AGC Control Modes, Governor Droop Operating Modes, Operating Reserves During PSR Conditions, Typical Generator Response Capabilities & Describe PRC-024-3 Requirements With Respect To Generator Ride-Through During Frequency Excursions
  - The Synchronizing Process Including The Theory Of Synchronizing, Synchronizing Islands During Restoration, The Voltage Phase Angle Concept, The Process For Reducing Phase Angles To Allow CB Closing & State The Roles Of The RC & TOP When Synchronizing During A PSR
- Explain & Illustrate The Content Of Each Of The Requirements Within NERC's Restoration Related Reliability Standards Including:

- List & Explain The Content Of Each Of The 16 Requirements In EOP-005-3: “System Restoration From Blackstart Resources”, Concentrating On The Role Of The TOP In Power System Restoration
- List & Explain The Content Of Each Of The Eight Requirements In EOP-006-3: “System Restoration Coordination”, Concentrating On The Role Of The RC In Power System Restoration
- Provide A Brief Description Of Actual Restoration Events & Describe The Lessons Learned From These Events Including:
  - November 9, 1965: Great Northeast Blackout
    - Need For BSRs & Detailed PSR Plans
    - Need For Operating Entity Coordination
    - Describe & Illustrate The Concept Of An Impedance Cascade & Explain The Content Of The Standard PRC-023-4: “Transmission Relay Loadability”, That Was Eventually Created To Address Events Such As An Impedance Cascade
    - Need For UFLS
    - Importance Of Re-Energizing Critical Loads
  - July 2, 1996 & August 10, 1996: WECC Events
    - Describe The Importance Of Vegetation Management & Explain The Content Of The Standard FAC-003-4: “Transmission Vegetation Management”, That Was Eventually Created To Address Events Such As This Vegetation Induced Disturbance
    - Importance Of Dynamic Reactive Reserve
    - Need For TOPs To Share Real-Time Operating Data Such As Transmission Line Outages
    - Concept Of An Impedance Cascade & The Need For Transmission Loadability Rules
    - Need For GOPs To Inform Their TOP Of Actions That Reduce Available MVar Support
  - August 14, 2003: Ohio Event
    - Need For RC & TOP Situational Awareness Including The RC’s Wide-Area View
    - Need For Accurate RC & TOP RTCA Applications
    - Need For Trained & Empowered System Operators
    - Need For Timely System Operator Load Shedding Actions
    - Concept Of An Impedance Cascade & The Need For Transmission Loadability Rules
    - Importance Of Vegetation Management
    - Importance Of Dynamic Reactive Reserve & Explain The Content Of The Standard VAR-001-5: Voltage & Reactive Control, That Was Eventually Created To Ensure TOPs Have Sufficient Dynamic Reactive Reserve

- July 2, 2011: Pacific Southwest Event
  - Need For System Operators To Have Situational Awareness Including Knowledge Of Pre & Post-Contingency Voltage Phase Angles
  - Need For Accurate Next-Day Operating Plans & Explain The Content Of The Standard TOP-002-4: Operations Planning, That Requires That BAs & TOPs Have Accurate Next-Day Operating Plans
  - Value Of Sharing Real-Time Operating Data Between TOPs & RCs
  - Need For Monitoring Status Of Non-BES Equipment
  - Need For RC To Provide Leadership During & Following Disturbance Events
- February 2021: Extreme Cold Weather Event
  - Need For Stronger Rules For Resource Planning
  - Impacts Of Extreme Cold Weather On Generator & Fuel Supply Availability & Explain The Content Of The Standard EOP-012-1: Extreme Cold Weather Preparedness & Operations, That Was Eventually Created To Address The Operation Of Generators During Extreme Cold Weather
  - Contrast Load Shedding In Response To A BA's Negative ACE Versus Load Shedding To In Response To Transmission Congestion
  - Need To Avoid Shedding Critical Loads (Such As Gas System Compressors) During Load Shedding Events
  - Need To Ensure That Dual-Fuel Units Maintain Appropriate Fuel Storage

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## **18. TOP Concepts & Standards Webinar Topics (10 CEH / 10 Standards)**

### **Learning Objective: Describe & Illustrate The Concepts & Content Within NERC's Reliability Standards TOP-001-5, TOP-002-4, TOP-003-5 & TOP-010-1(i)**

- Describe & Illustrate The Concepts & Content Within NERC's Reliability Standard TOP-001-5
  - Topics Addressed Include A Description Of The Roles Performed By The RC, TOP, TO, BA, GOP, GO & DP; Concept of Wide-Area; Concepts Of SOL/IROL & RC/TOP Roles With Respect To SOL/IROL; Difference Between The BES & BPS; Concepts Of Thermal Limit, Voltage Limit, Angle Stability & Cascading; Concept of Operating Instruction; Concepts Of BES Emergency & Adverse Reliability Impact; Concept Of RAS; Concept of Real-Time Assessment & A Description Of The Content Of The Requirements Within TOP-001-5
- Describe & Illustrate The Concepts & Content Within NERC's Reliability Standard TOP-002-4
  - Topics Addressed Include The Purpose & Content Of The TOP & BA's Operational Planning Analysis & Next-Day Operating Plan; Explanation Of The Value Of The Voltage Phase Angle For MW Flow Control; System Analysis & Monitoring; Concepts Of Synchronizing & Synch-Check & A Description Of The Content Of The Requirements Within TOP-002-4
- Describe & Illustrate The Concepts & Content Within NERC's Reliability Standard TOP-003-5
  - Topics Addressed Include The Need For Sharing Operational Data Between Operating Entities; Description Of The Content Of The Requirements Within TOP-003-4 & The Need For Addressing Extreme Cold Weather Conditions In Reliability Standards Such As TOP-003-5
- Describe & Illustrate The Concepts & Content Within NERC's Reliability Standard TOP-010-1(i)
  - Topics Addressed Include The Need For Real-Time Monitoring & Analysis; The Difference Between An Operating Process & An Operating Procedure; The Concept Of Real-Time Data Quality; The Need For An Alarm Process Monitor To Detect The Failure Of Real-Time Monitoring Capability & A Description Of The Content Of The Requirements Within TOP-010-1(i)

## **19. Transmission Line Protection Webinar Topics (10 CEH/5 Standards)**

### **Learning Objective: Describe & Illustrate How Transmission Line Protective Relaying Accomplished**

- Review Fundamental Concepts Of Power System Design & Protective Relaying
  - Topics Addressed Include Describe & Illustrate ANSI/ IEEE Device Numbering System, Describe & Illustrate Zone Of Protection Concept, Describe & Illustrate Purpose & Application Of Instrument Transformers, Describe & Illustrate Common Substation Bus Arrangements, Briefly Describe & Illustrate Concept Of Symmetrical Components & Describe Importance Of Protective Relay Maintenance & Testing As Mandated By PRC-005-1.1b & PRC-005-6
- Describe & Illustrate Key Concepts In Transmission Line Protection
  - Topics Addressed Include Describe & Illustrate Concept Of Differential Relay, Describe & Illustrate Concepts Of Overcurrent, Impedance & Distance Relays, Describe How Impedance-Based Fault Location Systems Work, Describe Differences In Protecting Radial Versus Looped Distribution / Transmission Systems, Describe Purpose & Illustrate Concepts Of Primary, Local & Remote Backup Protection, Explain Risks Versus Rewards Of High Speed Automatic Line Reclosing (HSAR) & Describe Importance Of Coordinating Transmission Line Protective Relay Settings As Mandated By PRC-027-1
- Describe & Illustrate Operation Of Common Types Of Pilot Protection Schemes
  - Pilot Schemes Addressed Include Direct Under-Reaching Transfer Trip (DUTT), Permissive Under-Reaching Transfer Trip (PUTT), Permissive Over-Reaching Transfer Trip (POTT), Directional Comparison Blocking (DCB), Directional Comparison Un-Blocking (DCUB) & Line Current Differentials (LCD). Other Topics Include Value Of Using Pilot Schemes To Avoid Issues With Transmission Loadability Requirements As Mandated By PRC-023-4

## **20. Voltage Control Webinar Topics (10 CEH / 6 Standards)**

### **Learning Objective: Describe & Illustrate Voltage Control Theory & Practice & Describe The Content Of NERC's Standards With Voltage Control Related Requirements**

- Describe & Illustrate The Concept Of Reactive Power
  - Topics Addressed Include An Explanation Of The Concept Of Reactive Power From An Energy Storage Perspective, Illustration Of How Reactive Power Flows, Illustration Of The Usage Of Shunt Capacitors To Compensate Inductive Load & The Derivation & Usage Of A Formula For Transmission System Reactive Power Usage.
- Describe & Illustrate The Causes & Effects Of Power System High & Low Voltage
  - Topics Addressed Include How Transmission Lines Both Use & Produce Reactive Power, An Explanation Of The Surge Impedance Loading (SIL) Concept, Illustration Of How Unscheduled Power Flow Leads To Low Voltage, Illustration Of How Transmission Line Trips Lead To Low Voltage, Explanation Of Why A Shunt Capacitor's MVar Output Varies With Voltage, Cause & Methods Of Preventing Ferranti Voltage Rise, Explanation Of The GMD Concept & Its Impact On Voltage Control, Description Of The Content Of EOP-010-1: "Geomagnetic Disturbance Operations" & TPL-007-4: "Transmission System Planned Performance For Geomagnetic Disturbance" As Related To GMDs, The Concept, Impacts & Control Of Harmonics, The Concept Of Sub-Synchronous Resonance (SSR), Description Of Low Voltage Issues When Starting Large Motors, Description & Illustration Of Motor Starting Methods Including Variable Speed Drives, Illustration Of How Point-On-Wave Closing Minimizes Capacitor In-Rush Current & An Explanation Of The Load/Voltage Relationship.
- Describe & Illustrate How Voltage Control Equipment Is Used To Control Power System Voltage
  - Topics Addressed Include The Usage Of Shunt & Series Capacitors For Voltage & Impedance Control, Concept Of A Super-Capacitor, Usage Of Shunt (Dry-Type & Oil-Filled) & Series Reactors For Voltage & Impedance Control, Description Of The Design & Operation Of Transformer Tap Changers, Usage Of Transformer Tap Changers For Voltage Control, Usage Of Generators To Both Absorb & Provide MVar, Description & Illustration Of Various Types Of Excitation Systems, Description & Illustration Of The Usage Of Reactive Capability Curves, Description Of MOD-025-2: "Verification & Data Reporting Of Generator Real & Reactive Power Capability & Synchronous Condenser Reactive Power Capability" Requirements For Creating Accurate Capability Curves, Description Of PRC-024-3: "Frequency & Voltage Protection Settings For Generating Resources" Requirements With Respect To Generator Voltage Disturbance Ride-Through, Description Of PRC-019-2: "Coordination of Generating Unit Or Plant Capabilities, Voltage Regulating Controls & Protection" Content & Purpose With The Standard's Compliance Represented On A Capability Curve, The Concept & Usage Of Thyristor & IGBT Based Equipment Such As SVCs, STATCOMs, Inverters

& HVDC Converters For Voltage Control & The Value Of Dynamic Reactive Reserve For Rapid Response To Voltage Deviations.

- Explain & Illustrate The Content Of Each Of The Requirements Within NERC's Voltage Control Related (VAR Series) Reliability Standards Including:
  - List, Explain & Illustrate The Content Of Each Of The Six Requirements In VAR-001-5: "Voltage & Reactive Control".
  - List, Explain & Illustrate The Content Of Each Of The Six Requirements In VAR-002-4.1: "Generator Operation For Maintaining Network Voltage Schedules".
  - List, Explain & Illustrate The Content Of Each Of The Six Requirements In PRC-010-2: "UVLS".