Training Title

POWER SYSTEM BLACKOUT - CAUSES & PREVENTIVE MEASURES AND SYSTEM RESTORATION TECHNIQUES

Training Duration

5 days

Training Venue and Dates

REF EE048	Power System Blackout - Causes & Preventive Measures and System Restoration techniques	5	24 – 28 May 2021	$6,250	Rome, Italy

In any of the 5 star hotel. The exact venue will be informed upon finalizing.

Training Fees

6,250 US$ per participant for Public Training includes Materials/Handouts, tea/coffee breaks, refreshments & Buffet Lunch

Training Certificate

Define Management Consultancy & Training Certificate of course completion will be issued to all attendees.

TRAINING DESCRIPTION

To successfully face, solve and operate the bulk and/or distribution electric power system when many unforeseen circumstances could happen every day to the power system, and can lead to a system wide outage/Blackout. The course will explain the different operation/restorative states including all system characteristics that are necessary before, during and after blackouts. For one, it is extraordinary, widespread black outs are rare, which is fortunate, but the consequence is that when they do occur, they pose severe and unusual problems. The ordinary task of system operation is that of guiding an ongoing, complex, highly automated process. The course will give guide lines and explain how to solve the problem with new approaches that make the restoration task is automated/friendly process.

Delegates are encouraged to raise queries both during and at any time after attending the course and are also asked to bring with them any technical issues that they may have.

TRAINING OBJECTIVE

The course will aid the operators to have good measures to prevent blackouts, how to stop spreading of the outage, can deal with network operation after black out and how to restore the system. Generic restoration strategy based on the expertise of experts will be conducted. The new methods to handle the subject will be introduced.

On successful completion of this course, participants will have:

- **A better understanding for the power system operation states**

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- **Black out causes and Restoration Principles**
- **A better understanding for the power system characteristics**
- **A better understanding for System Operations Challenges**
- **Understanding the Power System Restoration Issues**
- **Analytical Tools used for Power System Restoration**
- **Protective System Issues During Restoration**
- **Reactive Power Consideration**
- **Special Considerations in Power System Restoration**
- **New Approaches In Power System Restoration**

WHO SHOULD ATTEND?

This course is intended for Electrical Engineers, Electrical Supervisors and Electrical operators engaged in the operation and planning of power stations, transmissions and distribution of Electrical Electric Power system. It will be very effective for engineers / Operators working in electrical control centers. Participants require a good understanding of electricity and operation and possess some relevant experience.

TRAINING METHODOLOGY:

A highly interactive combination of lectures and discussion sessions will be managed to maximize the amount and quality of information and knowledge transfer. The sessions will start by raising the most relevant questions, and motivate everybody find the right answers. You will also be encouraged to raise your own questions and to share in the development of the right answers using your own analysis and experiences. Tests of multiple-choice type will be made available on daily basis to examine the effectiveness of delivering the course. Very useful Course Materials will be given.

- **30% Lectures**
- **30% Workshops and work presentation**
- **20% Group Work& Practical Exercises**
- **20% Videos& General Discussions**

COURSE OUTLINE

I. Black out and Restoration Principles

1. **Statement of the problem**
2. **Power System States Objectives**
3. **Black out causes**
4. **Power System Characteristics**
   a) **Structural Characteristics**
   b) **Dynamic Characteristics**

- **Characteristics Related to Reactive Power Balance**

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- **Characteristics Related to Active Power Balance**
- **Characteristics Related to Protection and Control System**

c) **Factors Affecting the Control of Frequency**

d) **Factors Affecting the Control Voltage**

5. **Restoration Process**
   a) **Restoration Stages (Three stages)**
      - **Stage One (Preparation)**
      - **Stage Two (System Restoration)**
      - **Stage Three (Load Restoration)**

   b) **Restoration Constraints**
      - **Physical Constraints**
      - **Scheduling Constraints**
      - **Policy Constraints**

   c) **Restoration Strategies (Three stages)**
6. **Restoration Planning**
   a) **Preparation**
   b) **Modeling**
   c) **Plan Development**
      - **Planning for First Stage**
      - **Planning for Second Stage**
      - **Planning for Third Stage**

   d) **Iteration**
   e) **Completion**

II.System Operations Challenges

1. **Introduction**
2. **The problem of upgrading energy management systems**
3. **Problems associated with predicting computer resource requirements**
4. **Effective Alarming**
   a) **Introduction**
   b) **Alarm Conditions**
   c) **Alarm Strategies**
5. **Problems In The-Design, Development, And Delivery Of Quality System Operator Training Programs**

III.Power System Restoration Issues

1. **Reactive Power Balance**
2. **Switching transient voltages**
3. **Interconnection assistance as Load and generation balance**
   a) **Frequency response of prime movers**
   b) **Cold load pickup**

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- Load and generation coordination
- Remote cranking power

4. Optimum sequencing of generating units startup
    a) Fault location
    b) Assessment of switching status
    c) Standing phase angles
5. Low frequency isolation scheme
    a) Intentional islanding
    b) Local load shedding
    c) Under-frequency and switched capacitor relays.

IV.Analytical Tools For Power System Restoration

1. Introduction
    a) Pre-disturbance Power System Conditions
    b) Post-disturbance Power System Status
    c) Types and Application of Analytical Tools
2. Island Detection Method
    a) Paths Determination
    b) Island Detection
3. Power Flow Application during Restoration
4. Load Shedding And Generation Tripping Application
    a) Introduction
    b) Hazards of Under-Frequency Operation
    c) Factors Affecting Frequency Decay
    d) Over-frequency Generation Tripping
    e) Frequency Load Shedding and Generation Tripping
5. Power Flow (PF) Program
6. Transient Stability (Ts) Program
7. Long-Term Dynamic (LD) Program
    a) Subsystem Sustaining Capability
    b) Response Reserve
    c) Restoration Load Frequency Control
8. Transient Voltage (TV) Program
9. Short-circuit (sc) program
10. Standing phase angle (SPA) reduction program
11. Cold load pickup (CL) program
12. Restoration coordination program
13. Restoration coordination program (CPM)

V.Protective System Issues During Restoration

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1. Minimum Source Operation and Distance Relays
    a) Distance Relays
    b) Fault Detectors
    c) Protective System Selectivity
    d) Minimum Source Guidelines
2. Lightly Loaded Lines and Negative Sequence Relays
    a) Negative Sequence Currents
    b) Negative Sequence Current Concerns
    c) Unsymmetrical Line Parameters
    d) Case Study
    e) Negative Sequence Current Operating Guide
3. Transformer Inrush Currents and Differential Relays
4. Other Relay Issues in Restoration
    a) Out-of-Step Relays and Controlled Islanding
    b) Excessive Standing Phase Angle and Synchro-check relays
    c) Plant Load Rejection and Low Frequency Isolation Scheme
    d) Excessive Core Flux and Volts Per Hertz Relays
    e) Under-Excitation and Loss-of-Field Relays
    f) Black Start and Generator Excitation Systems
    g) Load Shedding and Under-Frequency Relays

VI.Reactive Power Consideration

1. Reactive Power Balance
    a) Reactive Power Load and Generation
    b) Top-down and Bottom-up Restorations
    c) Top-down Strategy
    d) Bottom-up Strategy
    e) Overhead Transmission Line Parameters
    f) Underground Transmission Systems
2. Generator Reactive Capability
    a) Generator One-line Diagram
    b) Design and Actual Generator Reactive Capability Curves
    c) Case Study Under Peak-load Condition
    d) Test and Verification Procedure
    e) Operating Limit Identifications
    f) Case study Under Light-load Condition
3. Optimizing Reactive Power Resources
    a) Generating Unit Characteristics
        - Generator Ratings
        - System Bus Voltage Range

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- Generator Step-up Transformer Ratings
- Auxiliary Transformer Ratings
- Auxiliary Load

b) Tap Selection Procedure

- The GSU Transformer Tap Settings
- The AUX Transformer Tap Settings

VII. Special Considerations in Power System Restoration

1. Introduction
2. Excessive alarms during restoration
3. Return to Other Power System States
4. Switching During Restoration
   a) Switching Strategies
   b) Operability of Field Equipment
   c) Cold Weather Effects
5. Optimal Sequencing Of Starting-Up Generating Units
   a) Procedure for Determining the Start-Up Sequence
   b) Data Base Requirements
   c) Start-up Definitions
      - Load Reject
      - Black Start Capability:
      - Ramp Rate
      - Hot Restart:
      - Cold Restart:
      - Restart Durations for Unit Types
      - Physical System Concerns
   d) Power System Concerns
   e) Telecommunication Capabilities And Limitations
6. Cold Load Pickup – Modeling
   a) Thermostatically-controlled loads
   b) Manually-restarted loads
   c) Fixed loads
   d) Modeling Approaches
7. Cold load pick-up-low voltage network loads
8. The role of Gas turbines restoration plan
9. Current operation
10. Restoration plan
11. Reactive power balance

VIII. New Approaches In Power System Restoration

1. Introduction
2. System-wide coordination and overall organization

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3. **Full automated restoration**
    a) **Computer aided restoration**
    b) **Cooperative restoration**
        - **Database building**
        - **Target selection**
        - **Planning of steps to reach the target**
        - **Implementation**
4. **Expert Systems For Power System Restoration**

    a) **General**
    b) **Knowledge Representation**
    c) **Inference Engine**
        - **Forward Chaining**
        - **Backward Chaining**
    d) **Survey of Expert System for Power System Restoration**
        - **Functional Objectives of the System**
        - **Power System Representation and Modeling**

NOTE:
Pre & Post Tests will be conducted
Case Studies, Group Exercises, Group Discussions, Last Day Review & Assessments will be carried out.

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