ICTD
المركز العالمي للتدريب والتطوير
International Centre For Training & Development

EE163
Power System Blackouts, Restoration and Troubleshooting

H.H. Sheikh Sultan Tower (0) Floor | Corniche Street | Abu Dhabi – U.A.E | www.ictd.ae | ictd@ictd.ae

Course Introduction:

Power system loads continue to grow in size and complexity. Reliability expectations continue to rise. Power systems themselves become larger and more complex in response to growing load and customer expectations. Indeed, power systems have become more difficult to analyze and operate. Recent power system blackouts have heightened the concern for power system security and, therefore, reliability. Major blackouts of electric power systems in which many customers are left without power are rare events. However, the effects of blackouts, for instance, can be catastrophic. It has been observed that protective system failures are a contributing factor in a large proportion of these blackouts during system disturbances.

Nowadays, power systems are operating with lower and lower security margins. This is due to the prioritization of the electricity market deregulation, the load consumption increase, the difficulties to build new facilities such as transmission lines and large power plants, etc. Consequently, the vulnerability of power systems becomes a very important issue and the probability of large blackout tends to increase, as confirmed by the various incidents experienced in the past. Therefore, mastering the knowledge of different topics related to blackout inception and power system instability has become essential for researches and engineers involved in power system planning, operation and control.

This course is designed to help power system professionals, planners and engineers gain ground on the power system blackout and restoration. This course provides an up-to-date description of the restoration methodologies and implementation strategies practiced internationally. Participants will learn how to identify precursors for blackouts and will practice the steps necessary to prevent them from occurring. The course will focus on mechanisms of blackouts, instability phenomena, modelling and analysis tools, preventive and curative measures and finally service restoration.

Course Objectives:

Upon successful completion of this course, the delegates will be able to:

- Apply a comprehensive knowledge on power system blackouts and prevention
- Determine the blackout concerns and review recent blackouts, its causes and lessons learned from these incidents
- Identify the various instability mechanisms and transients and analyze the cold inrush current effects on blackout
- Recognize the role of induction motors in triggering blackouts

- Evaluate the functions of angle and voltage stability control in power system blackouts and become acquainted with the process of assessing security margins with respect to voltage instability
- Implement the blackout preventive measures and identify the process of wide-area monitoring and control
- Discuss the power system restoration including the analytical tools for power system restoration, system operations challenges, protection relays issues during restoration and the heuristic approaches to distribution system restoration
- Determine the special considerations in system restoration such as black start capabilities, tie line utilization during power system restoration and the usage of HVDC links in power system restoration
- Employ the new approaches in power system restoration namely knowledge-based systems, real time considerations, MARS, etc
- Use a structured approach on system restoration planning in consideration to the tools, guidelines, techniques and procedures for system restoration plan implementation

Who Should Attend?

This course will be valuable to power system analysts and engineers, including generation and transmission planners, protection engineers, ISO/RTO technical staff, and operations supervisors. Others who will benefit include power developers and marketers, power exchange personnel, regulatory staff, and economic and management consultants.

Course Outline:

DAY 1:

- **Overview of Blackout concerns**
- **Overview Blackout Causes**
- **Review of Recent Blackouts, Causes and Lessons Learnt**
  - Self-organizing Criticality and the Edge of Chaos
- **Instability Mechanisms & Transients**
- **Cold Inrush Current Effects on Blackout**
- **Induction Motors Role in Triggering Blackout**

DAY 2:

- **Angle Stability Control**
- **Voltage Stability Control**

- Reactive Capability Limitation of Synchronous Machines
- Optimizing Generator Reactive Power Resources

- **Assessing Security Margins with Respect to Voltage Instability**

DAY 3:

- **Blackout Preventive Measures - Overview**
- **Wide-Area Monitoring and Control**
- **Blackout Prevention by General & Network Voltage Control**
- **Blackout Prevention by Compliance with Reliability Standards**
- **Blackout Prevention by Loads Voltage Stabilization**

  - Static VAR Compensators
  - Voltage Stabilizers
  - AGC Implementation
  - Role of HVDC Systems in System Stability

DAY 4:

- **Restoration Overview**
  - Power System Restoration-First Task Force Report
  - Analytical Tools for Power System Restoration-Conceptual Design
  - System Operations Challenge
  - Protection Relays Issues During Restoration
  - Overvoltage Control During Restoration
  - Effects of Cold Load Pickup at the Distribution Substation Transformer
  - Power System Restoration Issues
  - Asymmetry Issues in Power System Restoration
  - Steam Plant Startup and Control in System Restoration
  - A Framework for Power System Restoration Following a Major Power Failure
  - A Hierarchical Interactive Approach to Electric Power System Restoration
  - Heuristic Approaches to Distribution System Restoration

- **Special Considerations in System Restoration**
  - Power System Restoration-The Second Task Force Report
  - System Restoration and Black Start Capabilities
  - Tie Line Utilization During Power System Restoration
  - Using HVDC Links in Power System Restoration

- **New Approaches in Power System Restoration**
    - Knowledge-Based Systems
    - Real Time Considerations
    - Guiding a Power System Restoration with an Expert System
    - Expert System Requirements for Power System Restoration
    - A New Algorithm for Service Restoration in Distribution Systems
    - MARS: Decision Support for Restoration after Local Disturbances

DAY 5:

- **Blackout & Restoration Training**
    - Development of a Large-Scale Dispatcher Training Simulator and Results
    - Dispatcher Training Simulators-Lessons Learned
    - The Uses of an Operator Training Simulator for System Restoration
    - An Advanced Transportable Operator Training Simulator
    - Restoration Simulator Prepares Operators for Major Blackouts
    - Bulk Power System Restoration Training Techniques
    - Verification of an Advanced Power System Restoration Support System Using an Operator Training Simulator
    - Evaluating a Restoration Tool Using an Operator Training Simulator
    - System Restoration Guidelines: How to Set-up, Conduct and Evaluate a Drill

- **System Restoration Planning**
    - Policies for Restoration of a Power System
    - Analytical Tool Requirements for Power System Restoration
    - System Restoration Plan Development for a Metropolitan Electric System
    - Role of Interactive and Control
    - Computers in the Development of a System Restoration Plan
    - System Restoration-Deploying the Plan
    - Power System Restoration Planning
    - A Systematic Method for Power System Restoration Planning
    - From Generic Restoration Actions to Specific Restoration Strategies
    - Estimating Restoration Duration

- **Operators Perspective and Supporting Tools**
    - Graphic Displays and Human Factors Engineering

- Human Error Reduction Techniques
- Risk Management Software

Course Certificate:

International Center for Training & Development (ICTD) will award an internationally recognized certificate(s) for each delegate on completion of training.

Course Methodology:

A variety of methodologies will be used during the course that includes:

- (30%) Based on Case Studies
- (30%) Techniques
- (30%) Role Play
- (10%) Concepts
- Pre-test and Post-test
- Variety of Learning Methods
- Lectures
- Case Studies and Self Questionaires
- Group Work
- Discussion
- Presentation

Course Fees:

To be advised as per the course location. This rate includes participant's manual, and-Outs, buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Course Timings:

Daily Course Timings:

08:00 - 08:20	Morning Coffee / Tea
08:20 - 10:00	First Session
10:00 - 10:20	Coffee / Tea / Snacks
10:20 - 12:20	Second Session
12:20 - 13:30	Lunch Break & Prayer Break
13:30 - 15:00	Last Session