Distribution Network System Design and Planning
Course Introduction:

The course covers general aspects of transmission and generation, the planning and design of modern distribution systems. Computer-based planning and reliability is also important part of modern planning. This program is entirely devoted to the planning and design of modern distribution systems including computer-based planning and reliability.

Other topics covered are design, construction standards, implications of international standards, network information systems, correct/safe work practices and improvement of distribution systems for senior distribution engineers. Basic Concepts behind distribution design & planning process will be discussed including: business requirements, project management, technical design, accurate system design procedures, physical planning, cost management, service agreements, and negotiations.

Course Objectives:

Upon completion of this course, the participants will:

- Understand basics concepts of electrical power system distribution planning and design
- Understand Power Distribution System Economics
- Understand General Principles of Planning
- List Distribution System Planning & Design for Engineers and Technicians
- Identify Distribution Network Planning and Design Process Steps
- Comprehend Methodologies and Strategies of Power System Distribution Systems
- Understand Distribution Transformers, Grounding and Protection
- List Basic Concepts of Distribution Surge Protection
- List Basic Concepts of Switching Rates
- List Basic Concepts of System Losses
- List Basic Concepts of Distribution Planning and Reliability Assessment

Who Should Attend?

Electricity utilities personnel, electricity utility engineers, electricity utility technicians involved in electricity distribution systems planning and design. Anyone who has responsibility for the planning, architecture, design, construction, operation, and line and substation technicians and engineers.

Course Outline:

Power Systems General Background
• Basic Concepts
• Electricity Supply Industry
  • Transmission System Operator (TSO)
  • Transmission System Asset Owner (TAO)
  • Distribution System Operator (DSO)
    ▪ Basic Network Theory
      • Synchronous Machines
      • Balanced Short Circuit analysis
      • Synchronous Generators in parallel
      • Generator Operation on Infinite Bus
      • Synchronous Machine Characteristics
      • Salient Pole Generators
      • Automatic Voltage Regulators
      • Lines, Cables and Transformers
      • Overhead Line types and parameters
      • Representation of Lines
      • Parameters of Underground Cables
      • Transformers
      • Voltage Characteristics of Loads
      • Control of Power & Frequency
      • System Monitoring & Control
      • System Security & Emergency Control
    ▪ Basic Power System Economics
      • Basic Pricing Principles
      • Supply side and Demand side options
      • Load Management and Spot Pricing
      • Electricity Pricing and Markets
      • Demand Side Management
      • Transmission and Distribution Charging Mechanisms

Electricity Distribution Network Design Considerations
  ▪ Reliability
  ▪ Sizing conductors for load and for voltage drop
  ▪ Planning Distribution Networks
  ▪ Technical Considerations
  ▪ Equipment
    • HV Networks And Substations
    • Distribution Substations And LV Networks
    • Special Loads
Network Voltage Performance
- Computer Based Planning

What is a Distribution Network?
- Introduction
- Scope
- Regulatory and Economic Aspects
- Power Electronics in the Future Distribution Grid
- Virtual Power Systems for Active Networks
- Smart Grids
- Introduction to Distribution Systems and Power Circuit Analysis
  - Distribution Transformers, Grounding and Protection
  - Distribution Surge Protection
  - Understanding System Losses
  - Substation Engineering and Design
  - Distribution Planning and Reliability Assessment
  - Distributed Generation and Energy Storage Applications on Power Systems
  - Low-voltage Secondary Networks
  - Power Distribution System Economics

Structure and Characteristics of Distribution Network
- Introduction
- Characteristics of Distribution Networks
- Impacts of Distributed Generation on the Electrical Network
- Photovoltaic Systems Connected to the Network
- Voltage Control in Distribution Systems with Dispersed Generation
- Grid Integration of Wind Turbine Systems and their Ancillary Services Participation
- Reliability of Distribution Systems with Dispersed Generation
- Protection, Detection and Isolation of Faults in MV Networks in the Presence of Decentralized Production
- Load Control in the Management of Distribution Systems
- Decentralized Means of Production
- Connection to the Decentralized Production Network
- Busbars that represent "electrical nodes"
- Network reliability determines the choice of substation structure
- Concepts and constraints concerning the load
- Load characteristics
- Transmission and distribution systems operators
- Quality and reliability requirements and economical impact
• Distributed generation
• Integration of new technologies
• Transfer on the electricity vector
• Desired evolution of the distribution system towards intelligent systems
• The link between investment and quality
• Financing mechanisms and investment actors of distribution systems

Electricity Distribution Network Design and Planning
• Characteristics of Distribution Networks
  o Signal characteristics: voltage level and frequency
  o Distribution networks structures
  o Protection plan
  o Characteristics of loads
  o Characteristics of faults
  o Rules of connection
  o Voltage levels and standards relative to proper functioning of North American-type distribution networks
  o Protection of the electrical network
  o Elements specific to the electrical network
  o The Supply System
    ▪ The primary aim of the electricity supply system
    ▪ Planning distribution networks
      ▪ The planning and design of electricity distribution networks
    ▪ Strategic or long-term planning
    ▪ Major investments and the main network configurations
    ▪ Network planning or design vs. construction design
      • Network Design & Planning
        o General Principles
        o Plant & Circuit Ratings
        o Project Design
        o Fault Levels
        o Short Circuit Rating
        o Protection
        o Interconnections
        o Asset Replacement
        o Costs
        o Voltage Limits
        o Load Balancing
        o Load Flow
- System Assessments
- Reinforcement Methods
- Weather Corrections
- Load Growth Trends and Analysis
- Design and Planning V & kV
- Plant & Ratings
- Parameters
- Interconnections
- Midterm and Long Term Planning
- Plant & Cable Capacities
- Loadings & Voltage Drops
- Layout Designs
- Domestic & Commercial Supplies
- Industrial Supplies
- Planning Consent
- Legal Aspects
- Sensitive Areas
- Project Assignment
  - Technical Considerations
    - Technical Design
    - Thermal Ratings
    - Voltage Regulation
    - Quality of Supply
    - Calculations and Models
      - Normal and abnormal operating conditions
        - Effect of the loss of any item of equipment on the supplies to customers
        - Quality of supply, e.g. voltage fluctuations
        - Amount of time a customer may be off supply
        - Safety of the public and the utility staff
        - Effect of transient and permanent system faults on both utility and customer-owned equipment
  - Power Distribution Network Design
    - Knee frequency (fknee)
    - Target impedance (ztarget)
    - Voltage regulator modules (vrms)
    - Capacitors
    - Plane capacitance
    - Interconnection inductance
Effectiveness of capacitors
Methodologies for design
Distribution general conditions
Distribution planning code
Distribution connection conditions
Generator requirements
11 kV and 33 kV overhead line (pole lines) construction, rehabilitation and maintenance
11 kV and 33 kV Underground Cable installation, operation and maintenance
33/11 kV substation installation, testing and commissioning
11/0.4 kV distribution transformer testing, repairs and maintenance
  • Reliability
    o Frequency of interruptions
    o Duration of each interruption
    o Reliability of individual items of equipment, circuit length and loading, network configuration, distribution automation, load profile and available transfer capacity
    o Reliability aspects associated with the line equipment, including reclosers, sectionalizers, cutouts, series reactors, and current-limiting fuses
  • Economic Principles
    o Asset
      o Technical and economic assessments

Use of the Distribution System
  • Structure of Distribution Code
  • Distribution General Conditions (DGC)
  • Distribution Planning Code (DPC)
  • Distribution Connection Conditions (DCC)
  • Distribution Operating Code (DOC)
  • Distribution Operating Code
    ▪ Demand Forecasting
    ▪ Operational Planning
    ▪ Demand Control
    ▪ Operational Communications and Liaison
    ▪ Event Reporting
    ▪ System Tests
    ▪ Monitoring, Testing and Investigation
- Safety Co-ordination
  - Distribution Data registration Code
    - Generating Unit Data
    - Demand Forecasts
    - Operational Planning
    - System Design Information
    - Load Characteristics
- Required Equipment
- HV networks and substations
  - High-voltage systems
  - Link between major transmission and medium voltage distribution systems
  - Single and multi-bus bar arrangement
  - Large open-air layouts or low-volume metal-clad switchgear in purpose-designed buildings
- Medium-voltage networks
  - Data on the present networks, design objectives, cost parameters and possible ways of reinforcement
  - Optimizing network configurations
  - Sophisticated network-design calculations
  - Quantitative information on the status of networks
  - Determining the most suitable future network configuration
  - Optimum circuit ratings.
  - Long-term planning and the study network reliability
  - Co-operation in network planning and design
- Workshops, Simulations, Case Studies and Group Projects
  - Capacity Planning Workshop
- Forecasting
- Design Calculations
  - Various theoretical, technical, economic and operational factors to be considered when planning and designing electrical distribution systems
  - Construction and operating characteristics of the main components installed on distribution networks
  - Main features of transformers, lines, cables and equipment
  - Switchgear arrangements
- System Protection
  - Electricity distribution network
  - Requirements for safety for individual items of equipment, staff and public, and the distribution network
  - Automatic operation
- Isolating faults on the networks in a minimum time in order to minimize damage.
- Minimizing the costs of non-distributed energy
- Substations and Protection
- Switchgear
- Line Protection
- Plant Protection
- Generator Protection
- Transformer Protection
- Feeder Protection
- Bus Bar Protection
- MV systems for distribution
  - Use of a single higher-voltage system (-kV) to supply local LV networks directly
  - Interlink the HV and LV systems
  - Material and construction costs of -kV overhead lines
  - Costs of V line and kV line
  - MV network between the EHV/HV and LV systems
  - Costs of HV/MV substations
- Distribution substations and LV networks
  - Comparison of low-voltage networks and distribution systems operating at higher voltage levels

- Load data
  - Parameters affecting the network design and timing of major reinforcements,
  - Forecast load
  - Developing effective and reliable routines
  - Determining the losses for a particular section of the network
  - Peak demand for the utility
  - Loads on distribution circuits
  - Calculating system loadings on a statistical basis
  - Special loads
  - Irregularities on the supply voltage
  - Steel-making arc furnaces, welding equipment, induction furnaces, rolling mills and colliery winders, and railway traction
  - Rapid variations in load currents and fluctuations in the voltage at customers' intake points
  - Load Control in the Management of Distribution Systems
  - Objectives of load control for the distributor
  - Controlled loads
  - Load control strategy: typical cycle
• Load control strategies
• Impact of the load shedding duration
• Impact of the ensured supply back
• Load control length time and amount of power to reduce
• Optimized load control
• Implementation of the algorithm
• Results for the optimized approach
  • Network voltage performance
    ▪ The quality of electricity supply
    ▪ Sudden changes in voltage, rapid fluctuations, or unbalance of -phase voltages
    ▪ Variations in frequency and the presence of non-linear system or load impedances
    ▪ Transient spikes and surges may be propagated along circuits in a supply system
  • Computer-based planning

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

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

Course Fees:

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

Course Timings:

<table>
<thead>
<tr>
<th>Daily Course Timings:</th>
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<tbody>
<tr>
<td>08:30 - 08:50</td>
<td>Morning Coffee/Tea</td>
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<tr>
<td>08:50 - 10:20</td>
<td>First Session</td>
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<tr>
<td>10:20 - 10:40</td>
<td>Recess (Coffee/Tea/Snacks)</td>
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<tr>
<td>10:40 - 12:20</td>
<td>Second Session</td>
</tr>
<tr>
<td>12:20 - 12:40</td>
<td>Recess (Coffee/Tea/Snacks)</td>
</tr>
<tr>
<td>12:40 - 14:30</td>
<td>Last Session</td>
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