Distribution Analysis – How’s Your System
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Apologies

- I tried getting it all done....but....
- Graphics
- References
- Examples
Objectives

- Methods and approach associated with performance of a distribution system assessment.

- What a distribution system analysis is and what makes up the elements of distribution system analysis studies.

- Deliverable output of the distribution assessment study and importance of the data and its impact and use on distribution operation and planning.
Distribution Definition

- System of components and facilities that transfer electric power from bulk delivery systems to customers.

- The main function of an electrical power distribution system is to provide power to individual consumer premises.
Distribution Components

- Components: equipment, assemblies, and portions which make up a distribution system
- Transformer, Switch, Fuse, Recloser
- Circuit components (cap bank, relays)
Why Perform Assessment

- Provides means and methods to determine ‘present’ state of power distribution system, associated equipment, functionality, and reliability.

- Provides means to determine the electrical and mechanical health of power equipment and power distribution system.
Why Perform Assessment

- Determines and discovers defects, deficiencies, hazards, or weaknesses in existing distribution systems – provides recommendations for correction.

- Grades issues and provides cost estimates to make corrections, upgrades, and maintain existing and future functionality and reliability.
Assessment vs. Analysis

- **Assessment** = process by which the overall condition of a system is discovered and documented to allow for understanding of existing conditions.

- **Analysis** = determination from computation and analytics of the operating characteristics and performance of a system.
Assessment vs. Analysis

- Assessment tells us what the condition is...
- ...Analysis tells us how it’s working
System Performance

- Reliability of equipment
- Lifespan of components (remaining)
- Cost of operation
- Cost of replacement
- Opportunity for upgrade and expansion
Cost of Failure

- Define what failure is
- Identify cost factors associated with failure
- Develop cost for each failure type
- Include intangibles
  - Customer satisfaction
  - Regulatory
  - Impact to capital projects, etc.
Equipment Included

- Power transformers
- Emergency generators
- Distributed generation sources
- Distribution transformers
- Distribution structures
- Protection & switching equipment
- Service Equipment
Outage Metrics

- **SAIDI** – system average interrupt duration index
- **SAIFI** – system average interrupt frequency index
- **CAIDI** – customer average interrupt duration index
- **CAIFI** – customer average interrupt frequency index
Assessment Steps

- System Definition
- Data Definition
- Field Assessment
- System Analysis
- System Valuation
- System Recommendations
System Definition

- Component based definition of types and range of equipment

- System boundaries
  - What will be included in assessment
  - Mapping system components
  - Identification of condition of any outside interconnections (closed system)
System Definition

- Identification of normal and emergency operating conditions
- Acceptable levels of operating
Data Definition

- Data sources – where are we getting information
- Define levels of data for each component type
- Inspection criteria for field inspections
Data Definition

- Data depository – how will data be gathered and stored
- Data review & verification – who reviews/assesses, how verified
- Customer feedback – used? How gathered?
Field Assessment

- Who will perform
- Data to be gathered (see data definition)
- System conditions during field assessment
- Static vs. dynamic inspections
- Data collation and storage
System Analysis

- Definition of levels of operating performance
- Method of analysis (simplified, standard, model)
- Type of analysis (risk, voltage, Markov)
System Analysis

- Analytical metrics for comparison (SAIDI, SAIFI, CAIDI, etc.)
- Results – components of concern
- More...later
System Valuation

- Value basis – how will system be graded (cost, performance, risk, etc.)
- Define acceptable value levels
- Comparison of assessment & analysis vs. value levels
- Deliverable is identification of components vs. value level
System Recommendations

- Identification of components of concern (analysis) and below value level (valuation)
- Identification of risks associated with these items
System Recommendations

- Cost analysis associated with risks
- Develop recommendations to improve system condition/performance
- Improvements must be linked to cost/risk or value levels
System Analysis
Method of Analysis

- **Simplified**
  - Qualitative
  - Informal procedures that analyses risk
  - Performed routinely thru brainstorming activities

- **Standard**
  - Qualitative or Quantitative
  - Formal procedures using risk and probabilities (risk matrices)
  - Documented process with formal results
Method of Analysis

- Model
  - Quantitative
  - Formal methods using event tree (ETA) and fault tree analysis (FTA)
  - Electric system simulation
Types of Analysis

- Risk (resilience)
- Voltage Profile
- Markov
Risk Analysis

- Risk analysis is quantitative means of analyzing system based on historical and expected system performance based on a cost-based valuation.

- Risk levels
  - Risk of breaking law/regulation
  - Risk of customer outage with repair costs
  - Risk of repair costs with no outage
Risk Categories

- Economic - net present value (NPV)
- Safety - simplified means, historical cost
- Environmental - risk matrix, NPV
- Supply (quality, source) - NPV
Risk Categories

- Reputational - risk matrix
- Vulnerability - system simulations, historical cost
- Regulatory - simplified means
Economic Risk

- Investment cost
- O&M costs (repair & damage)
- Cost of losses
- Customer outage costs (revenue & penalties)
- Congestion costs (LMP, constraint impacts)
Test Systems

- Used in place of developing model
- ‘Standard level’ of system performance

Versions:
  - IEEE Reliability Test System (IEEE-RTS)
  - Roy Billington Test System (RBTS)
Voltage Profile

- Comparison of voltage quality as means of identifying areas/components of concern, which are compared against acceptable voltage levels as means to analyze system.

- Method
  - Load flow solution taking into account real (kW) and reactive (kVAR) power by analyzing voltage magnitudes and angles throughout system.
  - Typically performed in normal and emergency load conditions.
Reliability Method Classes

- Simulation – most flexible but high computation & uncertainty of precision

- Analytical
  - Network modeling → most popular (voltage profile, ETA/FTA)
  - Markov

- Network modeling cannot easily handle dependent events: fault isolation, load restoration, complex protection systems
Markov Model

- System described by set of ‘states’
- Probability of moving to a new ‘state’ dependent on current state
- Includes hierarchical levels
  - System topography/configuration
  - Protection system behavior
  - Protection device behavior
- Reliability characteristics assigned to each component
Levels Within Model (reliability levels)

- No protection → fault = blackout
- Primary protection only
- Fault isolation thru sectionalizing
- Back feeding
- Back-up protection
Assessment Deliverables
Data Tables

- List, charts, tables of reference data used
- Typically included in native file format
- Assessment and analysis inputs
- Typically Owner owned data
Field Inspections

- Field notes, component information, photos
- Data acquired from drawings and field inspections
- Verification and additions to drawings
- Includes existing condition assessment
Updated System Map

- Preliminarily from Owner provided data
- Revised based on field inspections
- Submitted in Owner directed mapping/data format
Performance Analysis

- Developed from analysis results
- Combination of performance and condition reports
- Provides existing system performance capabilities and risks
- Identifies components of concern
System Valuation

- Associates cost values to each area of assessment
- Typically placed in NPV format
- Includes any risk associated cost revisions
- Combination of Owner data and assessment input
Improvement Section

- Addresses the component of concern
- Solutions to correct areas of performance that do not meet Owner performance guidelines
- Recommendations for future improvement with defined impact on performance
- Recommendations must be cost based (either NPV or FPV)
Summary
Why Perform Assessment?

- ‘Present’ state of power distribution system
- Electrical and mechanical health of power equipment and system
- Discovers defects, deficiencies, hazards, or weaknesses in existing system
- Grades issues for importance and magnitude
- Cost estimates to maintain existing and future reliability
Why Perform Assessment?

- Every system changes as equipment and components are changed, added, removed, or aged and as the load flow on the system changes.

- Not performing distribution analysis places system at risk for unintended consequences when system is altered by many changes that impact the reliability and function of the system.
Questions?
Need/Want More?
Additional Questions, Thoughts, or General Discussion

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