Chapter 7
Transmission Line
Reconductoring Process Analysis

ABSTRACT

The electrical transmission congestions transpire when scheduled or actual load flows across a line/substation are restricted by the desired levels – either physically or by the electrical line capacity. Several electric companies are aware of the congestion problems and the associated costs, where new transmission upgrades are oftentimes incorporated with new generation in close proximity with the load. Other companies are taking advantage of the benefits Smart Grid technologies propose that captures renewable energy production to defer the transmission upgrades based on the peak load growth. The industrial operations process analysis of the Line Rebuild project is an important cost-reduction mechanism to evaluate system integration. The value-added evaluation process provides the necessary front-end analysis for prudent decision-making of capital improvement endeavors.

OVERVIEW

The three most important structural elements that formulate an electrical distribution system are 1) transmission lines, which transmit high voltage electricity from power generation facilities, 2) substations, which decrease the voltage in the transmission lines to distribution levels, and 3) distribution lines, which convey the electricity to customers.

The Transmission Lines

Transmission lines are high-voltage conductors (60-kV or greater) that convey bulk power from remote generation sources to the electrical service area. Overhead high-voltage conductors are approximately an inch in diameter and are comprised of aluminum strands or a mixture of aluminum and steel strands. The lines are isolated electrically by the adjacent air and are not wrapped with
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insulation material (Fink & Beatty, 2001). The overhead transmission line is the standard technology to convey electrical power. Most damage to the overhead conductors is attributed to fault-current arcs. The conductors strands are significantly weaken from the enormous heat generated by the arc. The protection circuits are designed to prevent such occurrences; however, electrical utilities experience such burn downs (especially with covered lines) when instantaneous tripping schemes were not utilized or applied incorrectly (Barker & Short, 1996). Consequently, long outages may occur due to the high-impedance fault condition which is somewhat difficult to detect once the line plunges to the ground. Generally, the conductor can withstand significant temperatures for a few seconds and maintain its potency. However, if the relaying or fuse fails to clear the fault in a timely manner, the conductor anneals and loses strength. Additionally, connectors and splices are susceptible to weak links in overhead lines based on inferior engineering designs, hostile environment, and/or poor installation (Jondahl et al., 1991). Compression splices (squeeze in) and good component cleaning practices are essential for high-quality contact with the conductors.

Support structures for the overhead transmission lines range from single wood or metal poles and H-frame towers between 50 and 90 feet tall for lower voltage lines (i.e., 60-kV and 120-kV), to metal H-framed or lattice frame towers between 75 and 130 feet tall for higher voltage lines (i.e., 345-kV). The proposed single/double circuit steel lattice towers for a capital project in the western region are designed to convey 500-kV. The average heights of these towers are 120-160 feet (single) and 170-210 feet (double). It is not advantageous for circuits that serve the same substation to be located or double circuited in the same proximity to each other (e.g., in the same corridor or on the same pole). The consequences are less reliability because both circuits could be compromised by the same event (e.g., wind storm or lighting strike). Moreover, safety issues would increase from maintenance activities including working on energized lines because one circuit is designated to carry power. In cases where the circuits are serving separate substations, double circuit configurations would not have the same dependability issues provided that they are each serving other load centers and there is existing redundancy built into the distribution system. In some cases, these circuits can be situated on the same structure.

Transmission lines are designed in accordance with requirements of the National Electrical Safety Code (NESC), and speak to design issues such as the following (Clapp, 2006):

- Clearances between the lines and other characteristics, such as ground or water surfaces, roadways and railways, other conductors or communication wires, and buildings;
- Use of shield wires along the top of the transmission line to protect the conductors from lightning strikes;
- If an energized line plunge to the ground, high-speed relay equipment will sense this condition and actuate breakers that would de-energize the line a tenth of a second to half a second;
- Connection of metallic parts to an electrode in the ground (grounding) in order to protect employees and the public from the hazard of electric potential; and
- Principles for mechanical and structural design, selection of materials, and construction practices to ensure that towers, conductors, and insulators are sufficient to withstand normal and unusual loads, such as ice and wind, to ensure that pole spans are adequate to prevent conductor or structure failure, and to ensure that ample clearances are maintained.