Long Range Plan Analysis Tools and Methodology

1. Introduction

Con Edison's transmission system is assessed using a variety of system modeling and simulation tools to measure the transmission system's capabilities against design criteria. This is done for present and planned configurations at present and future load levels, respectively. The simulations are validated using real-time measurements made under normal and contingency conditions whenever possible. Assessments are made in the following areas using standardized software packages to study the system's performance:

- Load Flows vs. Thermal Facility Ratings;
- Voltage Profile;
- Short Circuit Current Levels vs. Equipment Capabilities;
- Stability;
- Critical Clearing Time;
- Underfrequency Load Shedding Adequacy;
- Transient Switching Surge and Lightning Withstand Capabilities; and
- Extreme Contingency Scenarios.

2. Load Flows vs. Thermal Facility Ratings

Load flow studies are the primary method used by Transmission Planning to assess the performance of the transmission system under normal and contingency conditions. The software used for these studies is provided by Power Technologies International, a division of Siemens AG, and is referred to as PSS/E, and acronym for Power System Simulator / Engineering. This is the dominant software package for load studies in the electric power industry.

The load flow levels determined from the studies are measured against the thermal ratings of transmission facilities, which are provided by Con Edison's Central Engineering Department. Facilities are assigned thermal ratings for

normal operation, long-time emergency operation (LTE), and short-time emergency operation (STE).

Load flow studies are conducted to simulate normal operation under peak forecast loads, followed by various contingency conditions defined in the New York State Reliability Council (NYSRC) and the Northeast Power Coordinating Council (NPCC) rules. In these simulations, the transmission system must exhibit the capability to be returned to operation within normal thermal limits following the worst case contingencies within the time frame specified in the rules.

2.1. FERC Form 715

While load flow studies are conducted year-round by Transmission Planning for a wide variety of analyses, including planned expansions, real-time contingencies, etc., overall system-wide assessments are required once a year to support the NYISO's requirement to file FERC Form 715 Annual Transmission Planning and Evaluation Report. This is a comprehensive effort that includes updating the system model in terms of configuration and impedances, and adjusting the transmission system for optimum power flows. A battery of load flow base cases are developed for the FERC 715 filing that include present summer and winter seasonal cases, as well as five and ten year look-ahead cases. The future cases incorporate all planned changes such as additions, expansions, and retirements according to the scheduled timelines for these changes.

Load flow base cases developed for the FERC 715 filing are used for annual reviews of Installed Reserve Margin (IRM), a NYSRC requirement. Transfer limits for the local area are calculated by Transmission Planning using load flow studies, and these are used as inputs in Multi Area Reliability Simulations (MARS) conducted by Con Edison's Energy Management organization.

Load flow base cases developed for the FERC 715 filing are also used in the NYISO's Comprehensive Reliability Planning Process (CRPP) which is conducted annually looking out over a ten-year horizon. The first task in the CRPP is to conduct a Reliability Needs Assessment (RNA). If a reliability need or needs are identified in any or all of the ten years studied, a Comprehensive Reliability Plan (CRP) must be formulated to meet that need or those needs.

3. Voltage Profile

Voltages throughout the transmission system are checked using the same load flow studies that are used to make the thermal assessments described in the section above. The focus, however, shifts from the delivery of real power, measured in MW, to voltage support and control provided by reactive power, measured in Mvar. Voltages must remain within a prescribed range of 0.95 to 1.05 per unit through all contingencies studied under the NYSRC rules.

4. Short Circuit Current Levels vs. Equipment Capabilities

Short circuit studies are conducted using the ASPEN program. These are done to assess:

1. The ability of circuit breakers on the transmission system to interrupt fault currents and,
2. The ability of all equipment on the transmission system, including but not limited to circuit breakers, bus work, disconnect switches, and structural supports to withstand the mechanical forces associated with fault currents. Momentary forces generated within the first one-half cycle following the inception of a fault typically present the highest mechanical stresses.

The NYISO conducts semi-annual updates of its short circuit base case models. Significant data for these studies include system configuration, i.e., network topology, impedances of all connected equipment, and circuit breaker interrupting ratings. All short circuit base cases use all available generation to ensure that the maximum possible current levels are simulated.

5. Stability

Stability studies are performed using the dynamic simulation capability of the PSS/E software. The studies encompass the full range of stability considerations on the power system, namely, steady-state stability, transient stability, and dynamic stability. These studies are very dependent on the detailed modeling of generator characteristics including excitation systems, control systems, inertia, and governor response.

Stability is assessed in accordance with NPCC Document A-2, "Basic Criteria for Design and Operation of Interconnected Power Systems". Document A-2 specifies a variety of faults and other contingencies, including stuck breaker conditions, through which the power system must remain stable. A provision is included for automatic reclosing which can be very effective in maintaining system stability following transient faults such as those induced by lightning.

NPCC Document B-4, "Guidelines for NPCC Area Transmission Reviews", states that stability assessment is to be part of the Comprehensive Review conducted once every five years in each of the NPCC Areas. The NYISO conducts the Comprehensive Review for the New York Control Area. Beyond this requirement, Con Edison undertakes stability studies when planned system changes have potential stability implications. In some cases, the studies are quite specific, targeted on a particular vicinity of the system. In other cases, the studies are broad in nature, encompassing a widespread territory. Transmission planners must use their experience and engineering judgment in determining the boundaries for such studies. Otherwise the studies become unwieldy and the results can be difficult to interpret.

6. Critical Clearing Time

Critical clearing time studies, like stability studies, are performed using the dynamic simulation capability of the PSS/E software. These are subsets of stability studies done with the intent of determining the allowable time intervals for protective relays and circuit breakers to sense and isolate faults without

causing generator instability or unstable oscillations (power swings) on the system. Worst case fault clearing scenarios are investigated, including stuck breaker conditions. The results of critical clearing time studies are often used to set the time delays on breaker failure relaying schemes to determine if existing settings are adequate.

Critical clearing time studies are by their very nature voluminous given the number of combinations and permutations to be considered in a typical complex transmission system. New studies are undertaken for significant planned changes to the system.

7. Underfrequency Load Shedding Adequacy

The adequacy of the underfrequency load shedding program is also assessed using the dynamic simulation capability of the PSS/E software. Simulations for the Con Edison service territory are conducted. In addition, the Company participates in NPCC Study Group SS-38 which conducts simulations that encompass all areas in the NPCC region. Underfrequency load shedding has been implemented throughout the NPCC to address imbalances between generation and load when electrical islands are formed due to major disturbances. Adequacy is affected by the extent of the imbalances, as well as by the dynamic response of the generators. The nature of the load modeling can also impact the study results.

While the NPCC keeps a close eye on the adequacy of its underfrequency load shedding program through its SS-38 Study Group, there is no prescribed interval for periodic studies. Studies are undertaken when engineering judgment dictates that system conditions have changed sufficiently to warrant a review of the existing program.

8. Transient Switching Surge and Lightning Withstand Capabilities

The ability of the transmission system to withstand transient switching surges and surges due to lightning is assessed using the Electromagnetic Transients Program, known throughout the industry as EMTP. These type of studies, while not explicitly required by any of the various industry oversight entities, are conducted by electric utilities to ensure that planned expansions are designed in a manner that will not impose transient stresses beyond the capability of equipment on their system, either existing or new. Scenarios studied include energizing and de-energizing, fault clearing under normal and stuck breaker conditions, backfeed conditions, potential resonance conditions, etc. Occasionally, studies are conducted to address unusual or unexpected electrical phenomena observed on the transmission system in real time operation. From a technical perspective, these are very sophisticated studies that require detailed modeling of system parameters and even the specific electrical characteristics of equipment.

EMTP studies can identify a need for surge arrestors, and determine the required capability thereof. They can also identify a need for shunt reactors to mitigate transient overvoltages, even in cases where they would not be required for normal voltage control.

9. Extreme Contingency Assessment

Extreme contingency scenarios that stress the transmission system beyond its design criteria are assessed in accordance with NPCC Document B-4, “Guidelines for NPCC Area Transmission Reviews”. Document B-4 states that extreme contingency assessment, similar to stability assessment, is to be part of the Comprehensive Review conducted once every five years in each of the NPCC areas. The NYISO conducts the Comprehensive Review for the New York Control Area. Beyond this requirement, Con Edison also periodically conducts extreme contingency assessments for its own transmission system. The intent is to gauge the extent of customer and overall system impact that

could be incurred under selected worst case scenarios involving multiple contingencies, and to identify potential mitigating actions that could be taken to minimize the adverse impact.