

II. CONTINGENCY ANALYSIS

Contingency Analysis (CA) is one of the "security analysis" applications in a power utility control center that differentiates an Energy Management System (EMS) from a less complex SCADA system. Its purpose is to analyze the power system in order to identify the overloads and problems that can occur due to a "contingency".

Contingency analysis is abnormal condition in electrical network. It put whole system or a part of the system under stress. It occurs due to sudden opening of a transmission line. Generator tripping. Sudden change in generation. Sudden change in load value. Contingency analysis provides tools for managing, creating, analyzing, and reporting lists of contingencies and associated violations [6].

CA is used as a study tool for the off-line analysis of contingency events, and as an on-line tool to show operators what would be the effects of future outages.

- Security is determined by the ability of the system to withstand equipment failure.
- Weak elements are those that present overloads in the contingency conditions (congestion).
- Standard approach is to perform a single (N-1) contingency analysis simulation.
- A ranking method will be demonstrated to prioritize transmission planning [7].
- CA is therefore a primary tool used for preparation of the annual maintenance plan and the corresponding outage schedule for the power system.

III. TYPES OF VIOLATIONS

Line contingency and generator contingency are generally most common type of contingencies. These contingencies mainly cause two types of violations.

A. *Low Voltage Violations* -

This type of violation occurs at the buses. This suggests that the voltage at the bus is less than the specified value. The operating range of voltage at any bus is generally 0.95-1.05 p.u. Thus if the voltage falls below 0.95 p.u then the bus is said to have low voltage. If the voltage rises above the 1.05 p.u then the bus is said to have a high voltage problem. It is known that in the power system network generally reactive power is the reason for the voltage problems. Hence in the case of low voltage problems reactive power is supplied to the bus to increase the voltage profile at the bus. In the case of the high voltage reactive power is absorbed at the buses to maintain the system normal voltage.

B. *Line MVA Limits Violations* -

This type of contingency occurs in the system when the MVA rating of the line exceeds given rating. This is mainly due to the increase in the amplitude of the current flowing in that line. The lines are designed in such a way that they should be able to withstand 125% of their MVA limit. Based on utility practices, if the current crosses the 80-90 % of the limit, it is declared as an alarm situation. Different types of remedial actions to solve this problem are explained later in this paper [11].

IV. REMEDIAL ACTION SCHEME

Remedial Action Schemes (RAS) are the key components for any power system utility planning. These are the steps which the utilities need to take in order to get the system back to its normal operation. Remedial Action Scheme (RAS) as the name suggests are the necessary actions which need to be taken to solve the violations caused by a contingency. Remedial Action Schemes are also defined as Special Protection Schemes (SPS) or System Integration Schemes (SIS). The RAS is designed to mitigate specific critical contingencies that initiate the actual system problems. There may be a single critical outage or there may be several critical single contingency outages for which remedial action is needed. There may also be credible double or other multiple contingencies for which remedial action is needed. Each critical contingency may require a separate arming level and different remedial actions. The terms SPS and RAS are often used interchangeably, but WECC generally and this document specifically uses the term RAS.

Automatic single-phase or three-phase reclosing following temporary faults during stressed operating conditions may avoid the need to take remedial action. Appropriate RAS action may still be required if reclosing is unsuccessful [8].

V. TYPES OF REMEDIAL ACTION:

- i. Shunt capacitor switching
- ii. Generation Re-dispatch
- iii. Load shedding
- iv. Under load tap changing (ULTC) Transformer
- v. Distributed Generation
- vi. Islanding

SINGLE CONTINGENCIES:

Whenever a transmission line or transformer is removed from service, we say that an outage has occurred. Outages may be planned for purposes of scheduled maintenance or they may be forced by weather conditions, faults or other contingencies. A line or transformer is deenergized and isolated from the network by tripping the appropriate circuit breakers. The ensuing current and voltage transients in the network quickly die away and new steady-state operating conditions are established. It is important for both the system operator and the system planner to be able to evaluate how the line flows and bus voltages will be altered in the new steady state. Overloads due to excessive line currents must be avoided and voltages that are too high or too low are not acceptable because they render the system more vulnerable to follow-on (cascading) outages. The large numbers (often, hundreds) of possible outages are analyzed by means of a contingency analysis or contingency evaluation program. Great precision is not required in contingency analysis since the primary interest is in knowing whether or not an insecure or vulnerable condition exists in the steady state following any of the outages. Accordingly, to test for the effects of line and transformer outages on the bus voltages and line flows in the network, approximate ac power-flow techniques are generally employed since they can provide a fast solution of the many test cases which need to be run.

MULTIPLE CONTINGENCIES:

Contingencies can arise in which two or more lines are tripped simultaneously, or where a line outage has already occurred and a shift in generation is being considered to determine if a line overload caused by the outage can be relieved. If tables of distribution factors for *first* contingencies are available, it is not necessary to recompute the tables in order to study the effect of two simultaneous contingencies. Although the existing distribution factors assume a normal system configuration before the first contingency occurs, they can be combined into formulas for evaluating *double* contingencies. Examples follow which illustrate how this can be achieved.

Suppose that line $(m) - (n)$ is carrying current I_{mn} before it trips out of service. If an overload occurs on another line $(i) - (j)$ due to the outage, it may be possible to reduce the overload by decreasing the current injected into the system at some bus (p) and correspondingly increasing the current injected at another bus (q) . Such current-shifting occurs when generation is shifted from a power plant at bus (p) to a power plant at bus (q) . The distribution factors of the preceding section can be employed to study this possibility of overload relief. Since the \mathbf{Z}_{bus} model is linear, the line outage and the proposed shift in current will have the same combined effect on the overloaded line regardless of the sequence in which the two events are considered to occur. For our purposes it is more convenient to consider first the proposed current shift and then the outage of the line $(m) - (n)$.