POWER NETWORK SEISMIC RELIABILITY ANALYSIS BY SIMPLIFIED PARALLEL AND SERIES SYSTEMS CONCEPT

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A power grid, as schematically represented in Figure 1 is mainly constituted of three main parts, namely; power plants, transmission and upper distribution substations and lines, and distribution grids.

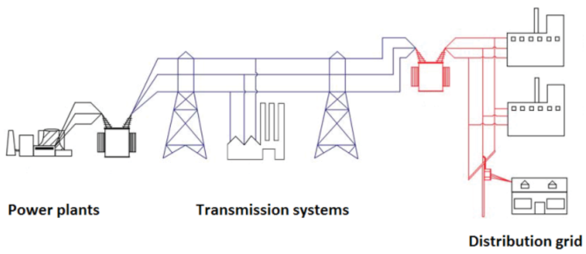

Figure 1. Schematic diagram of power network connections.

The assessment of the seismic performance of a power grid can be classif ed into three categories, as listed in bellow:

1- Components performance,
2- Power f ow inf uenced by components interconnectivity,
3- Stability and power balance within power grid.

The hierarchical structure of a power grid which is based on power delivery from higher voltage networks to lower voltage grid, can be considered as the basis for identi f cation of appropriate performance inside the power system. In Figure 2 the "Distribution Network" which feeds the consumers, is fed from an upper voltage grid namely , "Upper Distribution Network" which is fed in turn by the "T ransmission Network" and the "Power Station" as the power production source. The main idea of probabilistic modelling of power system is based on the fact that if each level of power delivery does not work then the delivery to the main consumer will fail. This will provide a simple probabilistic parallel and series model for the problem, which seems extremely complicated. The emerging idea is well matching the idea of reliability analysis of structures using interdependent modes of failure through which, the probability of failure of a structure is suggested to be calculated using the inclusive probability of collapse in modes of failure. Since the modes of failure are not considered to be independent, the inclusive probability of failure is estimated by calculating the upper and lower limits instead of looking for exact closed form solution. However, the power network failure analysis can be much more easily performed using probabilistic modelling of simultaneous independent events that is addressed in this paper.

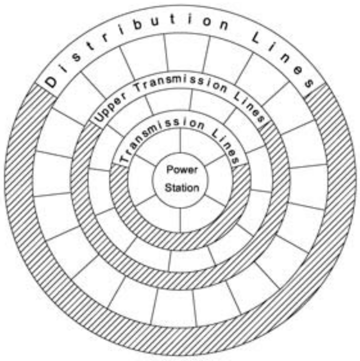

Figure 2. Simple Interconnection schematic modelling of power grid.

A study has been performed according to above mentioned methodology and the probability of outage for Yakhchi Abad district in Tehran (Figure 3) has been calculated in the case of an earthquake occurrence scenario. A sensitivity study showed that in the case of outage of 400 kV Firouz Bahram substation due to non-seismic effects like human made hazards or unbalance load shut down, the probability of outage of the district will increase by a factor of 1.43 while the other substations sensitivity factors vary in a range of 1.026-1.179. The sensitivity factor of the district power network to the "Distribution Grid" performance is very high due to immediate connection and the lack of redundancy as it is usually the case for the upper distribution and transmission systems.

Figure 3. Power network map under consideration.

Although the distribution network is showing the most important effect on the power delivery reliability in the case of seismic occurrence, but it is obvious that the risks of higher voltage outages are more serious due to the higher extent of consequences of higher voltage systems. The power flow sensitivity to transmission substation Firouz Bahram has shown around 1.6 compared to other substations with a sensitivity factor up to 1.15 which points out the importance of Firouz Bahram by a factor of around 1.5. This means that the mechanical strength measures of typical transmission substation equipment and structures should be considered greater in essence as compared to lower voltage installations.

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