FLEXIBILITY AND OPERATING RESERVES IN ELECTRIC POWER SYSTEMS

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One of the main characteristics of the flexibility of the electric power system is to maintain the efficiency of EPS when changing internal and external factors.

Depending on the purpose of flexibility application, all studies of flexibility can be divided into two groups: long-term planning and real time. Flexibility metrics can be probabilistic (IRRE) and deterministic [1].

The scientific articles describe different metrics of flexibility, among them:

1. Determination of the range of maximum uncertainties within which the system remains flexible for specified time horizon and cost threshold [1].
2. Calculation of IRRE (the insufficient ramping resource expectation). The probability distribution of available flexibility resources for each direction and time horizon is formed [2].
3. Calculation of the flexibility residual, which is the difference between the available flexibility and the expected load ramps for each observation and horizon. Then, the probability that the residual flexibility will be less than zero is determined, which means the probability of insufficient resources in the system [3].
4. Calculation of the ramping rate (ΔR), power (ΔP), energy (ΔE). These values are used to determine flexibility in EPS [4].
5. Calculation of flexibility sets, which determine the allowed deviations from the current state of the EPS. The method is based on computational geometry using polytopic projections, requires a limited amount of information exchange between two EPSs, can do without central coordination [5].

EPS flexibility is obtained via increasing and properly utilizing power reserves.

Additional capacity is provided either online or in on standby mode for use in the case of load increases or generation decreases due to unpredictability or variability of the conditions. In EPS with a large number of sources of variable generation (wind, solar), which can unexpectedly increase or decrease output power, it is important to have both upward and downward reserves [6].

When calculating the flexibility of EPS, it is necessary to have accurate information about the available power reserves in the EPS and the rules for using these capacities.

Scientific articles provide an overview of the operating reserves used in America and Europe [7]. Methodologies are presented with an emphasis on how reserve requirements can change with significant penetration of the generation variable in EPS [6]. In [8] methodology for determining the minimum required volumes of active power reserves of EPS of Russia is given.

In this study the flexibility of a 5-node EPS using the IRRE method is calculated. In the proposed network bus 1 is a wind turbine, bus 2 is a generation unit, bus 3 and 4 are loads, bus 5 is the BESS. Bus 2 is a slack bus.

References

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