The Model of Power Shortage Estimation of Electric Power Systems with Energy Storages

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The modern electric power systems with renewable plants contain energy storages. For analysis of generation adequacy of such systems we should take into account random character of generation, processes of accumulation and consumption of electricity from energy storages. We have efficient method based on Monte Carlo simulations for analysis of generation adequacy of traditional electric power systems. For adaptation of the method to modern conditions is necessary to modify the model of power shortage estimation.

Let's consider a scheme of electric power system which contains n nodes and set of system links. The given power system contains energy storages. Let N is number of simulated states of electric power system. Each system state is characterised of set of random values such as of available generating capacity $\bar{x}_i^k$, value of load $\bar{y}_i^k$ in node i, power line capacity $\bar{z}_{ij}^k$ between nodes i and j, $i = 1, \dots, n$, $j = 1, \dots, n$, $i \neq j$, $k = 1, \dots, N$. Storage capacity $\overline{\triangle x}_i$ is given for each node i.

Let x_i is power used at the node i, y_i is the power served at the node i, $\triangle x_i$ is variation of battery power condition at i-th energy storage, z_{ij} is power flow from the node i to the node j, $i = 1, \dots, n$, $j = 1, \dots, n$, $i \neq j$. I propose following new problem for power shortage estimation of system state with the number k

$$G \sum_{i=1}^{n} y_i + \sum_{i=1}^{n} \triangle x_i \to max,$$

$$x_i - y_i - \triangle x_i + \sum_{j=1}^{n} (1 - \alpha_{ji} z_{ji}) z_{ji} - \sum_{j=1}^{n} z_{ij} = 0, \; i = 1, \dots, n, \; i \neq j,$$

$$0 \le y_i \le \bar{y}_i^k, \; 0 \le x_i \le \bar{x}_i^k, \; -\triangle x_i^{k-1} \le \triangle x_i \le \overline{\triangle x}_i - \triangle x_i^{k-1}, \; i = 1, \dots, n,$$
$$0 \le z_{ij} \le \bar{z}_{ij}^k, \; i = 1, \dots, n, \; j = 1, \dots, n, \; i \neq j.$$

Here α_{ij} are given positive coefficients of specific power losses during electric energy transfer from the node i to the node j, $i \neq j$, G is weight number for raising of priority of minimization of power deficit, $G > 1$, $\triangle x_i^{k-1}$ are optimal meanings of variables $\triangle x_i$ of given problem for previous system state with the number $k - 1$, $i = 1, \dots, n$, $j = 1, \dots, n$, $k = 1, \dots, N$. Let's take any number from interval $(0, \; \overline{\triangle x}_i)$ in the capacity of $\triangle x_i^0$, $i = 1, \dots, n$.

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