2024

Certificate Authority Cup International Mathematical Contest Modeling

http://mcm.tzmcm.cn

Problem D (ICM)
Wind and Solar Farms

The generation of electricity from renewable sources, particularly wind and solar power, is rapidly increasing in many countries. These energy sources are gaining popularity due to their environmental benefits and low cost. However, they come with a significant challenge: their power output is highly variable and difficult to control. This variability poses a major obstacle to integrating these sources into existing electrical grids. To facilitate the incorporation of wind and solar generation facilities into conventional power networks, it is essential to address the challenges posed by generation variability, including system balancing, reserve management, and scheduling of generation units. As a result, forecasting and regulation methods are needed to help utilities and researchers predict wind speeds and solar irradiance over both short- and long-term time scales.

Tasks: The provided dataset includes one month of power generation data from 12 wind turbines in a wind farm and 11 solar power plants in a solar farm. The goal is to develop an effective mathematical model to address the following tasks:

1. Study the fluctuation patterns of power generated by the wind farm and solar farm separately. A forecast should be made before a significant decrease (at least 5 minutes in advance) or a significant increase (at least 2 minutes in advance) in total power generation. Let the power at the current time be denoted as p, and the average power over the last 30 minutes be denoted as q. The fluctuation magnitude is measured by $k = |p - q|/q$. A significant decrease or increase is defined when k exceeds a specified threshold value t. The value of t can be chosen by you, with the objective of achieving both a smaller t and a higher level of accuracy in forecasting.

2. Given that data is recorded at a frequency of 1 Hz, you are required to make separate interval forecasts for power generation over the subsequent 1–120 seconds.

3. Some power stations use a strategy where standby generators are kept in reserve to be activated when power generation decreases, and deactivated when generation increases. The goal is to design a scheduling scheme that keeps the fluctuation intensity below the specified threshold t with probability r, while determining the proportion of total generators to set aside as standby units, and when to activate or deactivate them. You can choose the values of t and r, with the aim of achieving both a smaller t and a higher r.

Note: You can download the data from:
`https://pan.baidu.com/s/17tixZWsH1UPF-nNNU7WFXw?pwd=7559`,
the password is 7559.