Solar Energy and Wind Energy Resource Evaluation Index

1. Variable Selection

According to “Technical regulations on the evaluation of national wind energy resources” published by National Development and Reform Commission of the People's Republic of China and “Assessment method for solar energy resource” published by State Administration for Market Regulation of the People's Republic of China, consider the accessibility and completeness of NASA POWER data, in addition with accuracy and simplicity, we select the following variables to build the wind and solar energy resource evaluation index, to compare the relative potential in the periods of our interest, as an application of our database.

Meteorology variables:

WS50M: The average wind speed at 50 meters above the surface of the earth.
WS50M_RANGE: The minimum and maximum hourly wind speed range at 50 meters above the surface of the earth.
WS10M: The average wind speed at 10 meters above the surface of the earth.
RHOA: The air density at surface of the earth.
WD50M: The average of the wind direction at 50 meters above the surface of the earth.
WS50M_MIN: The minimum hourly wind speed at 50 meters above the surface of the earth in the period of interest.

Radiation variables:

MIDDAY_INSOL: The total amount of solar irradiance (direct plus diffuse) incident on a horizontal plane at the earth's surface during the solar noon hour midday period.
AOD_55: The optical thickness at 0.55 um measured vertically; the component of the atmosphere to quantify the removal of radiant energy from an incident beam.
ALLSKY_SFC_SW_DWN: The total solar irradiance incident (direct plus diffuse) on a horizontal plane at the surface of the earth under all sky conditions. An alternative term for the total solar irradiance is the "Global Horizontal Irradiance" or GHI.
ALLSKY_SFC_SW_DIRH: The solar irradiance incident on a horizontal plane at the surface of the earth under all sky conditions.
ALLSKY_SRF_ALB: All sky rate of reflectivity of the earth's surface; the ratio of the solar energy reflected by the surface of the earth compared to the total solar energy incident reaching the surface of the earth.
CLOUD_AMT_DAY: The average percent of cloud amount during daylight.

2. Data Processing and Weight Allocation

We use entropy weight method to allocate weights to different variables.
Entropy Weight Method is an objective weighting method based on information entropy theory, which determines the weight of each index by analyzing the discrete degree of the data itself. The core idea is that the higher the degree of dispersion of the index data (the smaller the information entropy), the greater the discrimination of the index on the evaluation results, and the higher the weight should be given.

Here are the data processing steps, code are uploaded to the github.

Step1: Data Standardization:

Dimensional differences are eliminated and raw data is normalized to [0,1] intervals. According to the nature of the indicators, they are divided into:

Positive indicators (bigger is better): $X_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}$

Negative indicators (smaller is better): $X_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)}$

for variable j, sample i

Step 2: Calculate Indicator Proportions

Convert the standardized data into a probability distribution form:

$$p_{ij} = \frac{x_{ij} + \varepsilon}{\sum(x_{ij} + \varepsilon)}$$

ε is extreme small number
p_{ij} represents the proportion of the i-th sample in the j-th indicator.

Step 3: Calculate the Value of Entropy

$$e_j = -\frac{1}{\ln(n)} \sum p_{ij} \ln(p_{ij})$$

Step 4: Calculate the Coefficient of Difference

$$d_j = 1 - e_j$$

Step5: Determine the Weights

$$w_j = \frac{d_j}{\sum d_k}$$

3. Index Calculation

Filter the variables to only cover columns of our interest, then compute index and add into original data files, export to .xlsx files.