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Calculation and Application of Important Parametersin Wind Energy Resource Assessment of Wind Farm Based on T-S Fuzzy Linearization

Logensh Sainei*

University of New South Wales Sydney, Australia

**corresponding author*

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Abstract: In recent years, the construction of wind farms has increased rapidly, and the evaluation of wind energy resources is an important basis for wind farm construction and one of the key factors for success or failure. The accuracy of wind energy resource evaluation, that is, the study of wind energy evaluation methods is particularly important. The purpose of this article is to calculate and apply the important parameters in wind farms based on fuzzy T-S linearization, to study and analyze the calculation process and algorithm of important parameters of wind energy resource evaluation, and to design and develop the corresponding wind energy resource evaluation system. The energy resource evaluation system and the corresponding parameter algorithm are implemented to make the system easy to use, accurate in calculation and accurate in evaluation. Finally, the system is used to calculate the simultaneous wind speed and annual average wind speed of each wind height (15m, 55m, 75m) of a wind farm in 2020. The annual average wind speed at the wind height is 7.16 m/s, and the annual average wind speed at the wind marker at 75 m is 8.07 m/s. In addition, the average wind speed of each anemometer in the first year first increased and then decreased with time, reaching a maximum value at 8:00 or 12:00.

1. Introduction

The state has formulated a series of policies to guide and encourage the construction of wind farms and the development of the wind power industry. The basis and basis of wind farm development and construction is the assessment of wind energy resources, that is, after judging and evaluating the quantity, quality and distribution, the type, installation location and height of wind farms are selected [1]. The calculation process and basic parameter data in wind energy resource evaluation are complex, and it is difficult to calculate and calculate accurately and quickly manually.

Therefore, the calculation and application of important parameters in wind energy resource evaluation of wind farms based on T-S fuzzy lines are studied, which can accurately and conveniently evaluate wind energy resources, and then calculate the wind energy resources of wind farms [2].

Because wind resources are abundant all over the world, and the geographical environment of all countries in the world meets the requirements, the development and utilization of its energy is no longer bound by politics, so wind has become one of the main new energy sources. Golkhandan R K presented a strategy for WTG control in LFC smart grids. Air flow is controlled by implementing a fuzzy logic controller with three input air velocities, frequency deviation and air velocity difference per second. The control takes into account each WTG, an advanced pitch controller that helps to quickly reduce frequency deviations due to sudden storms. In addition, the participation coefficient of the frequency deviation signal is determined by a learning-based intelligent controller (BELBIC) for determining the rotor speed deviation [3]. Farbood M proposed a quadratic programming (QP) method for variable parameter predictive control design model based on T-S fuzzy model. In this way, the minimization of the cost function is transformed into a QP problem, thereby reducing the computational complexity. This reduction in complexity leads to increased management efficiency. The experimental results show the effectiveness of this method compared with previous methods [4]. Kolahdooz investigated the effect of different casting conditions on the microstructure of cold cast aluminum alloy A356. The simulation is performed by a CFD code called FLOW3D. The diameter and shape size of the primary α-Al particles from the experiments and the presence time of the slurry in the gradient, the solid fraction of the slurry were investigated. The residence time of the slurry in the cooling ramp should be long enough to obtain better microstructure, higher rotation and smaller particle size [5]. So far, the feasibility study of foreign projects tends to be perfect.

This paper studies and analyzes the calculation process and algorithm of important parameters in resource evaluation of wind farms, designs and develops a corresponding wind energy resource evaluation system, and uses algorithm to make the system easy to use and accurate. The accuracy of calculation and evaluation. In addition to statistical data such as wind speed, wind direction, and wind density, the evaluation of wind power sources in wind farms also needs to investigate and analyze important indicators such as wind shear index and turbulence intensity to determine installation. Therefore, the accuracy of wind energy resource assessment is crucial to the actual power generation and benefits after wind farms are built.

2. Research on Important Parameters in Wind Farm Wind Resource Assessment Based on T-S Fuzzy Linearization

2.1. Parameter Description of Wind

(1) Wind direction

Refers to the direction the wind is blowing, generally determined by the wind vane. The wind direction is usually expressed in 16 azimuths, which are generally caused by atmospheric circulation and vary with the seasonal average. Long-term observation of the wind direction in a region can obtain the number of wind direction observations in each azimuth, which can be divided by the total number of observations in the statistical period to obtain the wind direction frequency in each azimuth [6-7].

(2) Wind speed

Wind speed refers to the distance of airflow per unit time, generally expressed in m/s. In order to describe the wind speed more comprehensively, several parameters are often used to describe the wind speed in applications [8-9]. Instantaneous wind speed refers to the wind speed measured by an anemometer at a given time; average wind speed refers to the average wind speed observed over a period of time [10-11].

(3) Wind energy and wind energy density

Wind energy refers to the kinetic energy generated by wind movement, representing the amount of wind energy resources stored in nature. The weight of the wind is measured by the weight of the wind and the cube of the wind speed. Therefore, wind speed has a decisive influence on the accuracy and scientificity of wind energy assessment, and wind speed plays an important role in the calculation of wind energy density [12-13].

2.2. T-S Fuzzy Linearization of Nonlinear Processes

Triangular, trapezoidal or Gaussian membership functions can be selected according to the size of the nonlinear measure in the divided region Ev [14-15]. The quasi-steady-state wind speed Vmean is selected as the scheduling parameter, that is, θ=Vmean. Therefore, in the vicinity of each discrete steady-state operating point, the following T-S fuzzy rules can be obtained:

$$\begin{aligned} &Rule\ \ i: \\ &IF\theta\ is\ M_i(\theta), \\ &THEN\ \dot{x}_s = f_s^i(x_s,\theta) + B_s u_s \end{aligned} \tag{1}$$

Among them, i=1, 2.., mss, mss is the number of discrete steady-state operating points.

The Jacobian linearization of fi(xs, 0) with respect to x” is performed near the operating point corresponding to θ, and the T-S fuzzy model under the fixed operating point can be obtained:

$$\begin{aligned} &Rule\ \ i: \\ &IF\theta\ is\ M_i(\theta), \\ &THEN\ \dot{x} = A_i(\theta)x + Bu \end{aligned} \tag{2}$$

So far, the T-S fuzzy linearization model of the nonlinear process of the wind power generation system is obtained. Among them, the local linearization model shown in equation (2), under the corresponding gain scheduling parameter θ, its equilibrium point is the origin [16-17].

2.3. Wind Energy Resource Assessment of Wind Farms

The main purpose of wind energy resource assessment in wind farms is to serve the setting of wind turbines in wind farm construction. Such small-scale wind energy resource assessments can also provide key technical support for the current focus on decentralized development. The resolution requirements are relatively high. Generally, the resolution is below, and we need to use a small-scale model for simulation calculation [18].

3. System Design and Research

3.1. The Overall Structure of the System

Considering the needs of users for the wind energy resource evaluation software system, the wind energy resource evaluation system initially created five modules: main module, system structure, data management, data analysis and financial analysis, as shown in Figure 1.

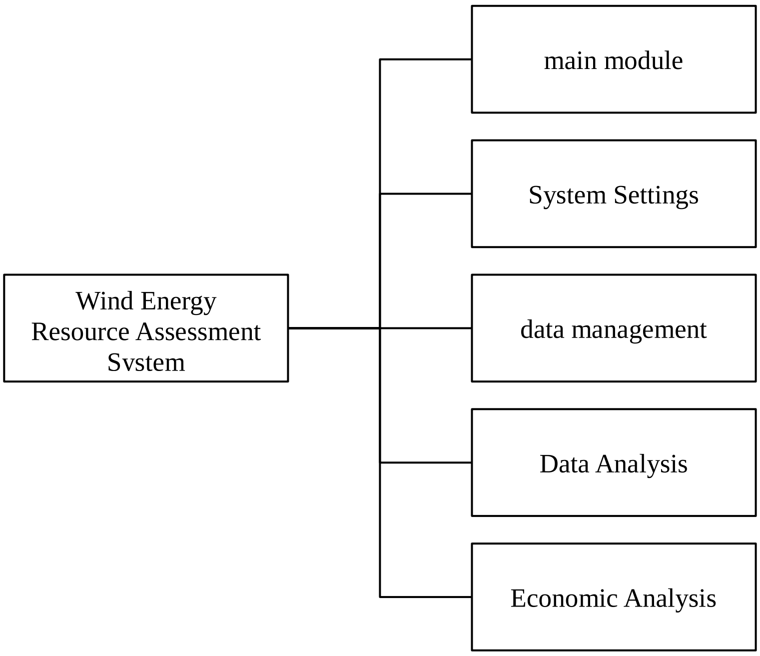

Figure 1. Overall structure of the system

Main module: control the data flow of the entire system.

System setting: mainly completes the selection and setting function of system parameters.

Data management: provide data input and output interfaces.

Data analysis: This module includes the main analysis functions of the software, which can analyze the original data as follows: annual power generation calculation, wind power density and average distribution of wind speed in each month of the year.

Economic analysis: Check the investment of each path of each investment, support services and operating income each year, and finally accept the average annual visit time, annual average total income, current average, etc.

3.2. Database Design

The design of the database is directly related to the realization of system functions and the efficiency of program operation. Before data import, there must be a basic data table, that is, the city of Inner Mongolia Autonomous Region and the existing weather station site data, and then according to the user imported data. The data dynamically generates data tables for corresponding regions and sites, and their existence is to store the actual measurement data of the wind farm more efficiently. The data of the wind energy resource assessment system of Inner Mongolia Wind Farm is stored in the form of relational database, which is simple to operate, easy to maintain, safe and reliable.

3.3. The Specific Implementation Environment of the System

Combining with the actual design of the system, it can be known that the B/S mode and JAVA language are mainly used in the selection of the Inner Mongolia Huayi wind energy monitoring and management system mode. The detailed implementation environment of Inner Mongolia Huayi wind energy monitoring and management system is as follows.

Required CPU: Quad-core and above

Required memory: 32G

Software: Windows Server 2012r2

Java SE Development Kit 7

SQL Server

Network communication requirements: 1000M network card *2

4. Calculation of Wind Energy Resource Assessment Parameters

4.1. Average Wind Speed

For wind farm A, the calculation results for all wind measurement heights (15m, 55m and 75m) in 2020 are shown in Table 1.

Table 1. Average wind speed and annual average wind speed at the same hour

Time	00	05	10	15	20	Average wind speed
15m	5.56	5.55	6.15	6.21	5.87	5.87
55m	6.87	6.85	7.56	7.35	7.16	7.16
75m	7.89	7.85	8.49	8.04	8.07	8.07

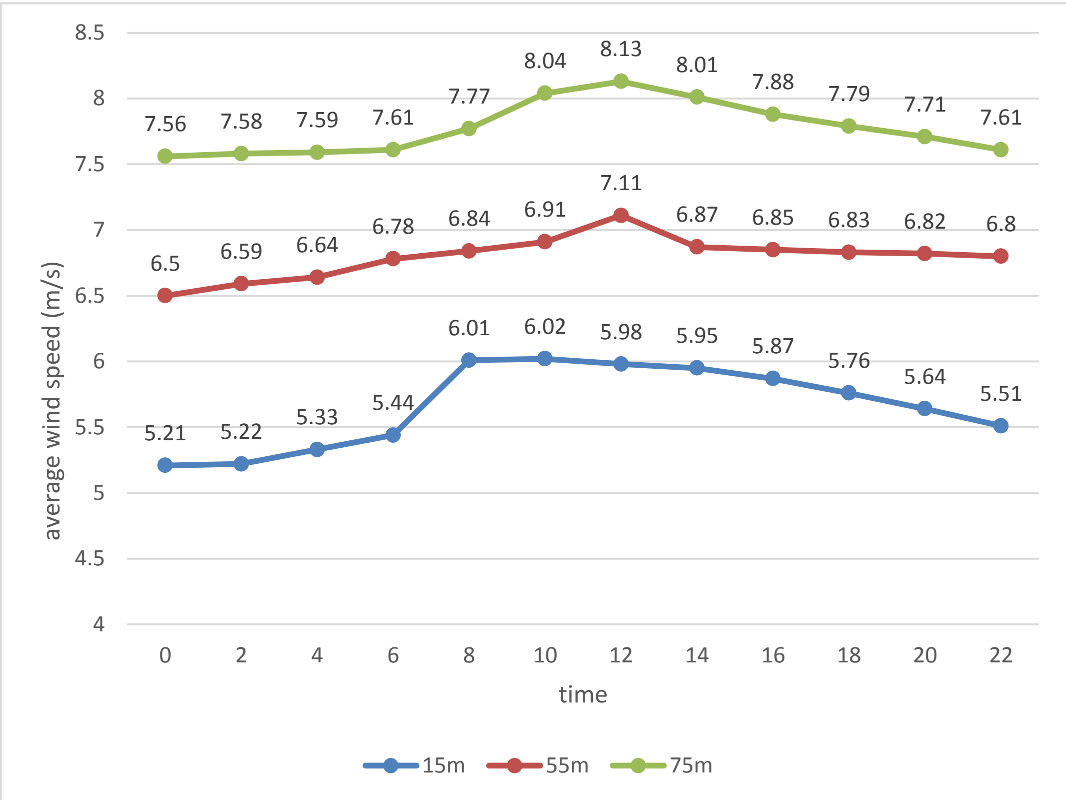

Figure 2. Average wind speed at the same hour throughout the year

From the calculation results in Figure 2, it can be seen that the annual average wind speed of the 15m wind measurement height is 5.87m/s. Among them, the variation range of the average wind speed at the same hour is between 5.21 and 6.02m/s for the 15m wind measurement height, 6.5~7.11m/s for the 55m wind measurement height, and 6.5~7.11m/s for the 75m wind measurement height. The variation range of the average wind speed at the same hour of the year at the wind measurement height is between 7.56 and 8.13 m/s.

4.2. Average Wind Power Density

Similar to the process of calculating the average wind speed, the calculation results of the wind power density and the annual average wind power density at the same hour of the year for all wind measurement heights (15m, 55m and 75m) in 2020 for wind farm A are shown in Table 2.

Table 2. Average and annual average wind power density at the same hour

Time	00	05	10	15	20	Average wind power density
15m	243.15	294.31	354.46	456.87	365.14	342.79
55m	315.89	356.96	458.12	512.45	389.45	406.57
75m	453.14	498.36	545.87	613.45	489.64	520.09

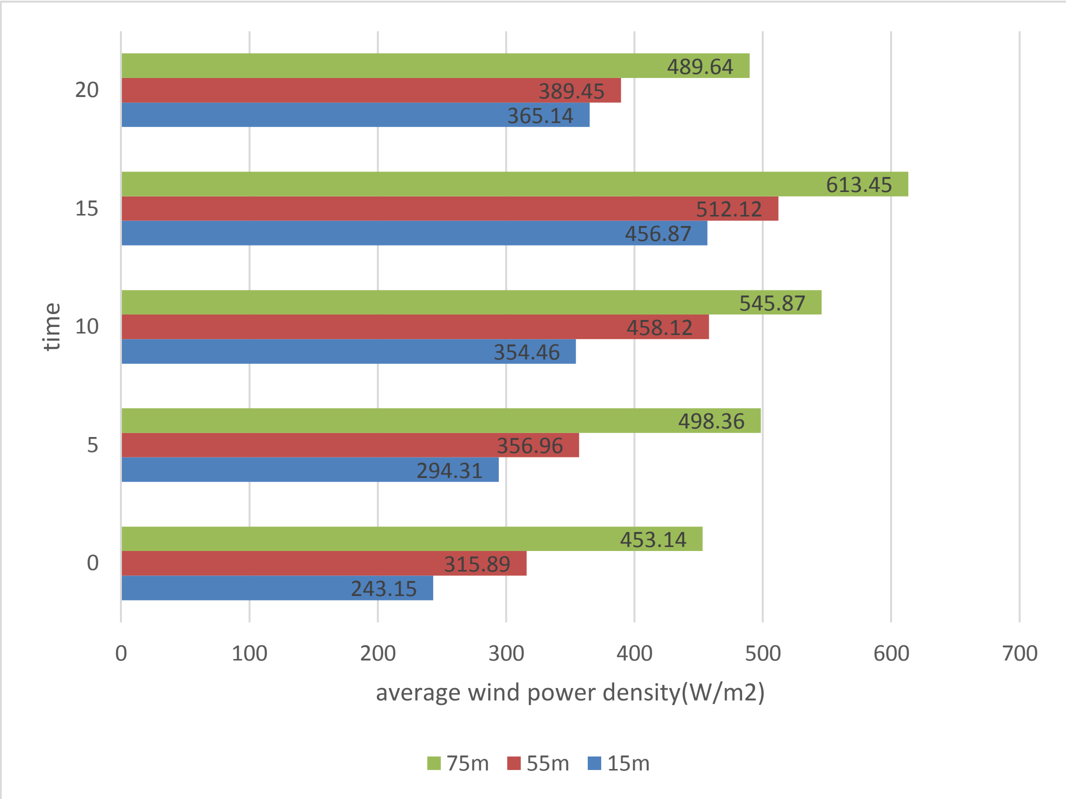

Figure 3. Average wind power density at the same hour

It can be seen from the calculation results in Fig. 3 that the average wind power at the same hour of the year at all wind measuring heights shows a trend of first increasing and all reach the maximum value at 15:00. Among them, the variation range of the average wind power at the same hour of the year at the 15m wind measurement height is between 243.15~456.87W/m2, and the change range of the average wind power at the same hour at the 55m wind measurement height is between 315.89~512.45W/m2 , the variation range of the average wind power at the same hour of the year at a wind measurement height of 75m is between 453.14 and 613.45W/m2.

5.Conclusion

In this paper, the evaluation methods of wind farms are deeply studied and analyzed, and the calculation methods of important parameters, and these algorithms are applied to the wind energy resource evaluation system of wind farms in Inner Mongolia. , and finally get the evaluation result. In a word, the establishment of a good wind energy resource evaluation system is very important for the site selection of wind farms in my country, and its impact on the wind energy industry and even the entire national economy is very far-reaching. In this context, learning the characteristics of various mathematical models and algorithms, and finding a wind energy resource evaluation system suitable for my country's national conditions, has an important and beneficial role in my country's wind energy development. Therefore, the research in this paper has the role of scientific discovery and practical technical guidance for the evaluation of wind energy resources in complex and remote areas in my country.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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