Capacity Credit Algorithm and Index of the New Energy of Wind Energy and Solar Energy based on Big Data

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Abstract. Since twenty-first century, many countries have accelerated their development, and the energy on the earth has been gradually consumed, which not only has caused the lack of energy, but also the environmental pollution. Therefore, people have paid much attention to the related problems. Based on the research of big data theory, the credibility algorithm of new energy was established in this paper. And through the establishment of wind farm power generation model, its reliability and indicators were analyzed. Thus, the feasibility of replacing old energy with new energy sources was explored. And through the analysis of the data, the reliability of wind farms and photovoltaic power plants was evaluated.

1. Introduction
When human society is constantly developing the economy, the shortage and excessive consumption of energy will inevitably follow, especially important energy sources such as natural gas, coal and petroleum (Budis, et al. 2013) [1]. Until now, the shortage of energy has begun to have an important impact on human life and production, which has seriously hindered the development of human society, and has also posed a certain threat to human existence (Budischak, et al. 2013) [2]. As a result, many countries have begun to pay attention to energy problems, and have gradually addressed the energy crisis from the aspects of energy saving and searching for alternative new energy sources (Blaabjerg, et al. 2013) [3]. Therefore, the research of solar energy and wind energy is attracting more and more attention (Zhao, et al. 2015) [4]. Efforts to save energy and reduce emissions can’t be separated from the strong support of the government, and our government has gradually promulgated many relevant regulations to support the solution of energy problems and the development of new energy sources (Li, et al. 2013) [5]. Therefore, the study of new energy is of great practical significance (Wan, et al. 2014) [6].

On the basis of big data theory, the capacity reliability of new energy represented by wind energy and solar energy was studied in this paper (Huber, et al. 2014) [7]. And by establishing the model of wind electric power generation, the capacity reliability of wind and solar power was studied scientifically and rationally in this paper, and the reliability index was also discussed (Ketterer, et al. 2014) [8].
2. State of the art

After years of painstaking research, researchers have found that the value of wind and solar energy has a very strong potential in the current alternative energy sources (Ma, et al. 2015) [9]. Researchers in many countries have paid close attention to it, and have done a lot of research into wind energy and solar energy, and as a result, many countries have mastered fairly mature technologies (Quan, et al. 2014) [10]. In terms of capacity for wind and solar energy, by 2014, it was able to use wind power to generate 53723MW. The annual growth rate of the global capacity has reached more than 20%, and it is still growing, and by 2020, wind power is expected to meet 15% of the world's electricity usage (Pedersen, et al. 2016) [11]. Therefore, wind energy and solar energy can provide a large amount of energy use capacity for human society, and can substitute for certain energy sources (Lydia, et al. 2014) [12].

In our country, there has been a great deal of research on the application of wind energy and solar energy (Ma, et al. 2014) [13]. Beginning in 2005, the installed capacity of new energy began to improve considerably, and by 2010, it surpassed the United States (Wan, et al. 2014) [14]. Therefore, China's new energy installed capacity has reached the world's leading position, and is still increasing every year (Ribeiro, et al. 2016) [15]. By 2015, China's installed capacity has reached about 20000MW. Common sources of energy can cause greater pollution to the environment. However, these alternative sources of energy can be renewed and will not pollute the environment, thus which is the main trend of energy application in the future.

3. Methodology

3.1. Research on the application of wind energy and solar energy

In the current world, the demand for electricity is changing with each passing day, and the degree of dependence is increasing with time. But fossil fuels used in the past are less abundant and would cause very serious pollution to the earth's environment, which requires human beings to gradually change the mode of energy use, and vigorously develop new energy research. In the field of alternative energy, more and more photovoltaic power generation applications have been realized by utilization of wind power generation and solar energy. Therefore, these new energy sources have also been used in various fields of society. At present, more and more wind farms have been built up, and more and more solar power products have been developed, so that new energy has come into every aspect of our life and production. Therefore, the randomness and volatility of new energy will have an important impact on the quality of power generation, which will lead to new risks. So, when using new energy sources like wind and solar energy to generate electricity, it must be tested in advance. Through the establishment of a power generation model, the capacity reliability of new energy generation can be fully assessed, so as to test the quality and level of new energy power generation. The scene of wind power is shown in Figure 1.

![Figure 1. The scene of wind power generation.](image-url)
When creating a wind farm model, the following important factors should be taken into account. The first factor is the natural randomness of wind energy. The arbitrary nature of the wind makes a big difference between wind power and traditional power, so that the unique nature of the wind should be considered and presented through a rational model. The second factor is to consider the ability of the machine to capture the wind in determining the speed of the wind. The influence of wind speed and wind force on height is put forward. The third factor is the need to take into account the relationships among machines at the time of input and output of wind and power. Therefore, when creating a wind farm model, it is necessary to consider the effects of various factors in the environment, and the intensity of light is particularly important. In this chapter, the creation of the whole wind farm model was studied, and the generation capacity of the two new energy sources, wind energy and solar energy, was evaluated, so as to lay a good foundation for the following research.

3.2. Research on capacity reliability of large new energy generation

Today, the shortage of energy and environmental pollution are becoming worse and worse, and more people are starting to focus their attention on the use of new energy sources, such as wind power and solar power. In addition many researchers have begun to pay attention to the significance of these new energy sources to human beings. It is well known that large-scale systems built from renewable sources have additional values of a certain capacity. Because the power itself will produce certain faults and failures, the equipment in the grid will also make mistakes. As a result, the capacity to be fully utilized in electricity is definitely less than the required capacity. Therefore, in the process of new energy power generation, due to the instability of energy, the energy capacity of different time is different. And the new energy power generation can provide a certain degree of capacity. Figure 2 shows the structure of the wind farm generation model system.

![Figure 2. System structure of wind farm generation model.](image)

The same thing with traditional energy sources is that renewable energy is not only capable of converting energy into electricity, but also has a certain capacity added value. And although the capacity credibility of renewable energy is different from that of conventional energy, the difference is still small. Therefore, starting from the point of view of the capacity reliability of the new energy power generation, the capacity reliability of new energy was calculated on the basis of big data in this paper. Then the results of calculation were analyzed, and the capacity confidence level of new energy was obtained. Because the principle of credibility of new energy capacity was put forward under the payload level of new energy, it can not only contain errors in the process of new energy generation, but also can fully consider the faults in the input current equipment. To assess the credibility of the new energy capacity level, it is necessary to establish the wind electric power generation model, so as to better analyze the capacity reliability of new energy sources. In the establishment of wind farm generation model, Matlab programming algorithm was adopted.

3.3. Research on design process of wind farm generation model

Because of the randomness of wind energy, it is difficult to control the ability of the wind. Many researchers have found that the power output of wind turbines depends mainly on wind speeds
captured by wind farm equipment, and therefore, wind speed has a greater impact on the capacity
reliability of new energy sources. In the process of building a wind farm model, two different models
should be considered respectively, and the energy storage configuration and voltage fluctuation level
of the site where the model is located should also be studied.

As wind power generation and solar power generation can produce capacity credibility, these two
new energy sources are more representative and have a bright future. Therefore, in this paper, wind
energy and solar energy were mainly studied. However, these two kinds of energy have the
characteristics of volatility and randomness, which are more unstable and will have adverse effects on
the system. Thus, it is necessary to establish a wind farm model and evaluate the credibility of new
energy capacity. Figure 3 shows the overall system architecture of the wind farm generation model
system and the important components of the model, such as hardware devices.

![Figure 3. Overall system framework of wind farm generation model.](image)

In this paper, in the process of building a wind farm model, the Weibull distribution method was
adopted in the design, and the wake effect was also used to simulate the wind speed captured in the
model. In addition, the Beta distribution was used to simulate the sun illumination that was perceived
in the model, thus making the establishment of the model more scientific and reasonable. In the
algorithm selection, the Monte Carlo algorithm was selected in the model. Thus, a reliability
evaluation model of generation and transmission system including new energy was created, and the
capacity reliability of the two energy sources of wind energy and solar energy was evaluated. In the
construction of wind farm generation model, the Matlab algorithm was chosen to design the system,
and the IEEE-RTS79 system was linked to accurately measure capacity reliability of new energy
sources.

4. Result analysis and discussion

Based on the creation of a wind farm generation model based on the principle of big data, the wind
farm generation model must be applied to the process of new energy power generation to evaluate the
capacity reliability of new energy sources. Through the above research, the Monte Carlo algorithm
was used as the basis of wind farm generation model, and the capacity reliability of the new energy
generation in the model was evaluated. In this paper, the data was collected, collated and summarized.
Table 1 shows the data obtained from the wind farm generation model applied to the credibility of the
new solar energy capacity.
Table 1. Application data of wind farm generation model.

| Project | Wind energy | Solar energy |
|---------|-------------|--------------|
| Device 1 | 6.87        | 8.75         |
| Device 2 | 2.35        | 7.78         |
| Device 3 | 8.05        | 7.51         |
| Device 4 | 8.83        | 7.87         |
| Device 5 | 9.59        | 6.42         |
| Device 6 | 8.57        | 6.61         |
| Device 7 | 9.89        | 5.95         |
| Device 8 | 6.28        | 1.22         |
| Device 9 | 6.80        | 5.68         |

Table 1 shows some of the level of wind farm generation models applied to the new solar energy capacity, which can explain the credibility of the capacity of new energy to a certain extent. Therefore, after collecting the relevant data of new energy, the data was deeply excavated and analyzed through big data technology, and the data was input into the wind farm generation model for calculation and analysis, and then a more accurate calculation result was obtained. Through the collection and analysis of the result data, a reasonable judgment about the role of the model in the capacity reliability of new energy was made. Table 2 shows the computational results of the wind farm generation model.

Table 2. Data calculation results of wind farm generation model.

| Project | Wind energy | Solar energy |
|---------|-------------|--------------|
| Device 1 | 4.15        | 1.38         |
| Device 2 | 5.30        | 6.95         |
| Device 3 | 1.33        | 3.79         |
| Device 4 | 4.46        | 3.10         |
| Device 5 | 6.27        | 1.79         |
| Device 6 | 5.67        | 4.88         |
| Device 7 | 6.52        | 3.60         |
| Device 8 | 5.40        | 4.88         |
| Device 9 | 2.82        | 1.71         |

The collected raw data was calculated through a wind farm generation model, and the function of the model in the capacity reliability of new solar energy resources was obtained. Therefore, the calculation results of the above data were analyzed, and the weight ratio of the reliability index of new energy resources was discussed to a certain extent, as shown in Figure 4.
There was a certain capacity value in wind power and photovoltaic power generation, and these two new sources of energy can replace traditional energy sources in the past. However, the capacity reliability of new energy sources remained to be further explored. On the basis of the above research, the following contents were studied through experimental methods and model building methods in this paper.

Firstly, the method of establishing wind farm and photovoltaic power plant model was studied. The Weibull distribution method was adopted to simulate the wind speed, and the wind speed of each unit was analyzed when the fan height was not the same. Finally, combined with the output power characteristics of wind turbines, a wind farm generation model was established. Then the Beta distribution was used to simulate the actual light intensity, and according to the illumination characteristics of photovoltaic array, the generation model of photovoltaic power station was established.

Secondly, the basic methods of reliability evaluation and the basic theory of Monte Carlo method were studied. The reliability model of generation and transmission system with large-scale new energy sources was established. And based on sequential Monte Carlo simulation algorithm, the sequence states of each component and transmission line in the system were determined. Moreover, the system reliability was evaluated by combining the system load model.

Therefore, through the above research, the following results were obtained: wind energy resources and solar energy resources are complementary to each other, and the complementary access mode can effectively reduce the fluctuation caused by individual access. As a result, the use of wind and solar complementary access mode can improve the reliability of the system more effectively than the individual access mode.

5. Conclusions

The formation rate of natural energy is far from being comparable to the rate at which humans consume it, thus resulting in a crisis of energy. In the search for alternative new energy sources, researchers from various countries have made some achievements after many years of research. In nature, new sources of energy, such as solar energy and wind energy, have become the major alternative to old energy. Therefore, in this paper, on the basis of big data research, the new energy was studied, and the reliability of new energy capacity was discussed. In addition, a wind farm generation model was established and applied to the study of the capacity reliability of new energy resources. The results show that the model can effectively improve the capacity reliability of new energy sources. Moreover, the index of capacity reliability was also discussed. Therefore, wind farm generation model plays a very important role in the capacity reliability of new energy sources.
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References
[1] Budischak C, Sewell D A, Thomson H, et al 2013 Cost-minimized combinations of wind power, solar power and electrochemical storage, powering the grid up to 99.9% of the time *J. Power Sources* **225** 60-74.
[2] Budischak C, Sewell D A, Thomson H, et al 2013 Corrigendum to “Cost-minimized combinations of wind power, solar power and electrochemical storage, powering the grid up to 99.9% of the time” [J. Power Sources 225 (2013) 60–74] *J. Power Sources* **232** 402.
[3] Blaabjerg F, Ma K 2013 Future on power electronics for wind turbine systems *IEEE Journal of Emerging and Selected Topics in Power Electronics* **1**(3) 139-152.
[4] Zhao H, Wu Q, Hu S, et al 2015 Review of energy storage system for wind power integration support *J. Applied Energy* **137** 545-553.
[5] Li X, Hui D, Lai X 2013 Battery energy storage station (BESS)-based smoothing control of photovoltaic (PV) and wind power generation fluctuations *IEEE Transactions on Sustainable Energy* **4**(2) 464-473.
[6] Wan C, Xu Z, Pinson P, et al 2014 Probabilistic forecasting of wind power generation using extreme learning machine *IEEE Transactions on Power Systems* **29**(3) 1033-1044.
[7] Huber M, Dimkova D, Hamacher T 2014 Integration of wind and solar power in Europe: Assessment of flexibility requirements *J. Energy* **69** 236-246.
[8] Ketterer J C 2014 The impact of wind power generation on the electricity price in Germany *J. Energy Economics* **44** 270-280.
[9] Ma K, Liserre M, Blaabjerg F, et al 2015 Thermal loading and lifetime estimation for power device considering mission profiles in wind power converter *IEEE Transactions on Power Electronics* **30**(2) 590-602.
[10] Quan H, Srinivasan D, Khosravi 2014 A Short-term load and wind power forecasting using neural network-based prediction intervals *IEEE transactions on neural networks and learning systems* **25**(2) 303-315.
[11] Pedersen M C, Sørensen H 2016 Towards a CFD Model for Prediction of Wind Turbine Power Losses due to Icing in Cold Climate *16th International Symposium on Transport Phenomena and Dynamics of Rotating Machinery*.
[12] Lydia M, Kumar S S, Selvakumar A I, et al 2014 A comprehensive review on wind turbine power curve modeling techniques *Renewable and Sustainable Energy Reviews* **30** 452-460.
[13] Ma K, Blaabjerg F 2014 Modulation methods for neutral-point-clamped wind power converter achieving loss and thermal redistribution under low-voltage ride-through *IEEE Transactions on Industrial Electronics* **61**(2) 835-845.
[14] Wan C, Xu Z, Pinson P, et al 2014 Optimal prediction intervals of wind power generation *IEEE Transactions on Power Systems* **29**(3) 1166-1174.
[15] Ribeiro A E D, Arouca M C, Coelho D M 2016 Electric energy generation from small-scale solar and wind power in Brazil: The influence of location, area and shape *J. Renewable Energy* **85** 554-563.