ISSN: 2664-9640

Distribution of wind power resources and Prospect of wind power generation in Tibet

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Abstract

Wind energy is a form of solar energy conversion, is a kind of renewable natural resources without any pollutant emissions, and the development and utilization of wind energy has a history of thousands of years. Driven by the depletion of fossil energy resources, energy supply security and environmental protection, since the mid-1970s, the world's major developed countries and some developing countries have attached great importance to the development and utilization of wind energy; Especially since the 1990s, wind power generation, the most important form of modern wind energy utilization, has developed rapidly. The annual average growth rate of the installed capacity of wind turbines in the world has exceeded 30%, rising from 2.16 million kilowatts in 1993 to 200 million kilowatts by the end of 2010. Compared with solar, biological, geothermal and marine energy power generation, the annual average growth rate of the installed capacity of wind turbines in the world has exceeded 30%, Wind power is a new energy with the most commercial scale development conditions in technology and economy.

Keywords

Tibet; Wind resources; Wind power generation; Prospects.

1. Introduction

With the acceleration of economic development and the improvement of people's living standards in Tibet, the energy development of Tibet Autonomous Region is facing increasingly prominent problems. Moreover, Tibet has a vast territory, and has not yet formed a unified power grid in the whole region, with long transmission lines, low user density and high construction and transmission costs. As a result, the power construction in some remote areas lags behind, especially in the vast agricultural and pastoral areas, the use of conventional power grid can not solve the problem of power consumption, There is a shortage of electricity. In many areas, the burning of traditional biomass energy is still the main way of energy consumption in many areas, which leads to excessive deforestation, serious damage to vegetation, and continuous deterioration of the ecological environment. How to establish a clean and convenient energy utilization mechanism to provide a reliable guarantee for the protection of Tibet's ecological environment has become a serious problem that the whole region of Tibet must seriously face[1].

2. Distribution of wind energy in Tibet

The total reserve of wind energy resources in Tibet is about 9.3 billion kw. H, ranking the seventh in the country. It is one of the areas with more strong wind (17m/s) in the country. The duration of strong wind is long, which is basically consistent with the dry season in winter and spring, and the wind energy resources are rich.

ISSN: 2664-9640

2.1. Average wind speed distribution

The Tibetan Plateau is one of the high value areas of wind speed distribution in China due to its high and open terrain and the influence of strong westerly momentum from high altitude. There are two gale areas in the whole region[2]. One is the area from northern Tibet to Ali, which is a gale area along the Heihe highway. The altitude of this area is more than 4500 meters. The mountain range is consistent with the trend of the torrent. The terrain is open and open, which is easily affected by the downward flow of the torrent. The other is the eastern part of the valley between the Himalayas and the gangdises. Because of its high terrain, it is easily affected by the downward transmission of rapid flow and the canyon effect, making it another strong wind area in the whole region. However, due to the influence of topography and altitude, there is basically no area with annual average wind greater than or equal to 5.0m/s in the whole region. The average annual wind speed is only 4.0-4.3m/s in northern Tibet and the eastern part of the valley between the Himalayas and the gangdises. The annual average wind speed of Pali, Cuona and Pulan in the South and Luolong in the East is 3.0-3.9m/s; Because Changdu and Mangkang in the East are located in the closed River Valley, the annual average wind speed is only 1.2m/s, which is the smallest in the whole region; The wind speed in other places is 1.4-2.9m/s.

In terms of seasonal distribution, wind energy is abundant in winter and spring, and the minimum in autumn. The average wind speed is 0.8-5.0m/s in winter, and the highest value is 4.1-5.0m/s in northern Tibet; In the spring with the highest wind speed in the whole year, the average wind speed in the north of Tibet reaches 4.5-5.0m/s; In summer, the wind speed is small, ranging from 0.9 to 4.1m/s in the whole region, and the maximum wind speed is 4.1m/s in Cuona and 4.0m/s in nyalamu on the southern edge; At this time, the wind speed along the northern Tibet line is 3.4-3.8m/s; The wind speed in autumn is smaller than that in summer in most areas of the region, and the high value is located in the northern and southern edge of Tibet, which is 3.2-3.9 m/s.

2.2. Distribution of wind power density

The maximum annual wind power density in Tibet basically corresponds to the maximum annual average wind speed. Most parts of northern Tibet are located in the range of 150-200m/s average wind energy density. Tibet is divided into two main wind belts: located in the northern Tibetan Plateau, roughly along the section of Naqu Ali highway (the northern Tibetan Plateau is the most windy area in Tibet, roughly ranging from Amdo in the East, to the north of Ali in the west, to Gangdise mountain and nyainqingtanggula mountain in the south, The annual effective wind energy density is 130-200w/m^2, The effective wind hours are more than 4000h); In the eastern part of the valley between the Himalayas (the Himalayas have an average annual effective wind energy density of 100-140W/m^2 and an average annual effective wind hour of 3500-4000h). The average wind energy density of most areas in eastern Tibet is below 50W/m^2, the average wind energy density near Lhasa and some areas in eastern Tibet is 50-100W/m^2, and the average wind energy density in southern Tibet is 100-150W/m^2.

According to the regulations of "national wind energy resources evaluation technology", the wind power density at 10m height in wind energy resource rich areas is greater than 200W/m^2, The wind power density is 150-200W/m at the height of 10 meters in the area with abundant wind energy resources, Wind power density 50-150W/m at 10m height in available area, The wind power density is less than 50 W/m at the altitude of 10m in the barren area. Basically, Tibet can be divided into two areas, namely, wind energy utilization area and poor area. Wind energy resources available areas: North of Nyainqentanglha mountain, Naqu County in the East and Geji County in Ali Region in the west, with annual wind power density of 119-199W/m^2, The wind power density is 55-193W/m in the southern marginal area (i.e. the northern foot of Himalayas) and Luolong County in Changdu area. Poor areas of wind energy resources: in addition to the above-mentioned areas where wind energy resources can be used, vast areas of

ISSN: 2664-9640

Tibet (Southeast Tibet is relatively poor in wind energy resources). The wind energy density in Tibet is shown in Figure 1.

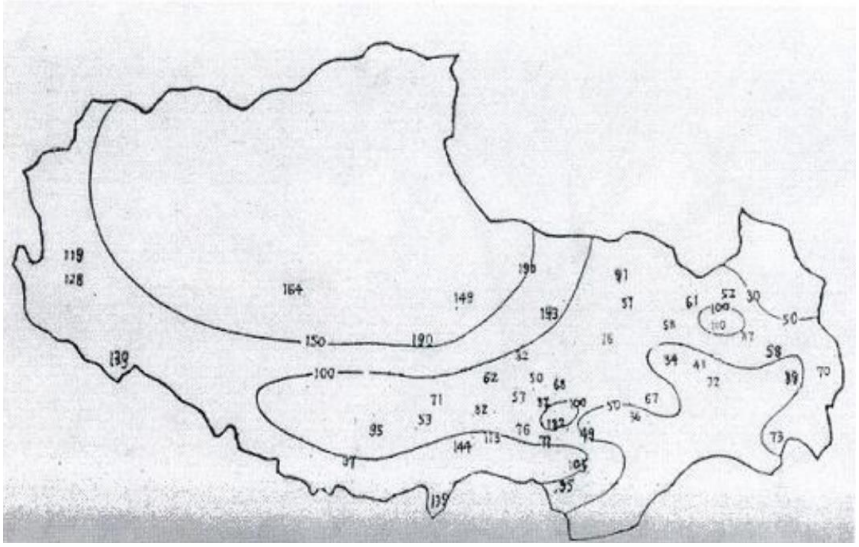

Fig. 1 wind energy density in Tibet

3. Influence of wind energy resources on wind power generation in Tibet

Due to the complex terrain, uneven distribution of wind energy resources (mainly concentrated in high altitude areas), uneven distribution of wind energy resources reserves and technological development, low air density, strong time period of available wind energy resources (mainly concentrated in winter and spring), large wind speed change and fast wind direction change in Tibet, the development and utilization of wind energy resources in the whole region is not only small in scale, but also small in scale, The number of projects implemented is also small. The main impacts of wind energy resources on the development and utilization of wind power are as follows[3]:

3.1. Limited generation capacity

Due to the lack of wind energy resource rich areas in Tibet, the existing wind power technology is still difficult to solve the problem of unstable output power of wind power. The feasibility of developing large-scale wind turbines and realizing grid connected power generation is very small. In addition, Tibet is a vast area with a small population density, most towns, townships and villages are small in scale, far away from each other, and the power consumption is relatively small, The investment and loss of long-distance transmission and distribution are very large, so it is not necessary to realize large-scale grid connected power generation.

3.2. The cost of power supply is high

The available wind energy resources in Tibet are highly time-consuming, mainly in winter and spring. If a single form of wind power generation is adopted, it is difficult to guarantee the power quality, reliability and stability. If the installed capacity is increased to meet the power demand when the wind energy is minimum in summer, the system cost will be increased.

Solution: fully utilizing photovoltaic power generation and wind power can not only solve the problems of strong time-consuming wind energy resources, difficult to guarantee the power quality, reliability and stability, but also overcome the disadvantages of high cost of solar power generation, and at the same time, the power generation quality, reliability and stability will be higher; When the active stall wind turbine is used, the blade pitch is pushed to the position where the maximum power can be obtained; When the wind turbine exceeds the rated power, the pitch of blade is adjusted to stall direction, and the power is adjusted to the rated value.

Because the change rate of power curve in stall range is much lower than that before stall, the control is relatively easy, and the output power will be more stable.

3.3. Influence of air density on wind power generation

The terrain of Tibet is high, and the air pressure decreases rapidly with altitude. The average annual air pressure is below 652.5kPa, less than 2/3 of the sea level, and the air density is 0.57-0.89 kg/m^3. If the air pressure value in plain area is 1, the air pressure values in Tibet are 0.71 in Linzhi, 0.66 in Lhasa, 0.62 in Naqu and 0.60 in Anduo. At the same temperature, the air density is directly proportional to the air pressure. The air density of plateau is only 60% - 70% of that of plain area. According to the Bates theory, the maximum power absorbed by the ideal impeller from the air source is Pmax = 8/27 ρSV^3. Under normal temperature and standard atmospheric pressure, the air density is 1.225 kg/m^3, and the relative air density is only 0.65 in Tibet with an altitude above 4 000m.

P(1)max/P(0)max=8/27 $\rho(1)SV^3$/(8/27 $\rho(0)S\ SV^3$)= $\rho(1)/\ \rho(65 \approx 2/3$, where: $\rho(1)$ is the air density at an altitude of 4 000m. That is to say, under the same wind speed, the fan impeller with the same parameters can only obtain 2/3 of the maximum power in Tibet, and the influence of air density on the energy extraction of wind turbine has been very significant[4].

Solution: the standard power curve of the wind turbine provided by the fan manufacturer is measured under the air density condition under the standard atmospheric pressure. The actual output power curve of wind turbine under air density in Tibet is different from the standard power curve, so the power curve of wind turbine needs to be modified, that is, the standard power curve of wind turbine is multiplied by the correction factor, and the power curve under low air density is selected; The design idea of concentrated wind energy type wind turbine is selected to overcome the weakness of low energy density of wind energy, and the rarefied wind energy is concentrated and utilized. In the process of concentration, the instability of wind energy is effectively overcome, so as to improve the efficiency and reliability of wind turbine and reduce the cost of wind power generation; Increase the installation height of the fan blade appropriately, so that the fan can obtain more wind energy and improve the power generation.

3.4. Influence of temperature on wind power generation

Air density ρ It will change with the temperature, generally when the temperature changes The corresponding air density changes at 10℃ ± 4%. The higher the altitude is, the lower the temperature is. The average temperature is above 16℃ and the extreme maximum temperature can reach 30-33℃ in Southeast Tibet at an altitude of about 2500m; In the Yarlung Zangbo River Valley with an altitude of 3500-4000m, the annual average temperature is 7-8℃, and the extreme maximum temperature is 27-29℃; The annual average temperature drops to -21℃ and the extreme maximum temperature is only 22℃ and the minimum temperature is below -40℃ in the grassland above 4500m above sea level. Due to the influence of temperature, the air density in Tibet is also low, which reduces the output power of wind turbines by 4%-8% compared with that in the mainland.

Solution: for variable pitch wind turbine, the blade pitch angle is controlled according to the feedback signal of generator output power, which is not affected by the change of air flow density. Whether the air density changes due to temperature change or altitude change, the variable pitch system can obtain the rated power output by adjusting the blade angle.

At the same time, the climate change in Tibet is sharp and the temperature difference is large. Except for the south slope of Himalayas, there are different degrees of frost in other places, and the northern Tibetan Plateau is the most serious, with frost free period less than 70 days. The critical state of rain, snow, fog and dew will freeze when encountering the surface of low temperature equipment and metal structure, and icing will do great harm to the safe operation of power system. The icing of blades of wind turbine will make the operation of wind turbine

unbalanced. The icing of anemometer, wind direction indicator and wind speed balancing device will affect the operation and control of wind turbine.

Solution: install electric heater inside the generator to solve the problem that large temperature difference is easy to cause condensation on the surface of generator winding.

3.5. Extremely dangerous by thunder

Lightning stroke is an important factor affecting the operation safety of wind turbine. According to the statistics of wind turbine failures in Germany, the annual lightning strike rate of every 100 wind turbines in wind farms is about 10%. Among all the external factors causing wind turbine failures (such as storm, icing, lightning strike and power grid failure), lightning strike accounts for about 25%. The biggest damage to wind turbine is the low peak lightning current. These fast changing lightning currents will produce transient magnetic field, which will cause harm to the surrounding electronic system through induction and radiation. This kind of harm may be potential at first, but it may cause accidents in the future operation of wind turbines. The Tibetan Plateau is characterized by high altitude, low air pressure, dry air, rainy nights in summer and thunderstorm days. The number of thunderstorm days in the plateau is 2-10 times more than that in the plain area of the same latitude in China, and it becomes the thunderstorm prone area with the largest number of thunderstorm days in the same latitude area of the northern hemisphere.

Solutions: strengthen the research and development of wind turbine lightning protection and grounding facilities, and do a good job in the maintenance and repair of lightning protection equipment.

3.6. The influence of sunshine

The generator of the fan is located in the narrow and closed engine room at high altitude, and the ventilation condition is poor. The motor should be closed structure, rely on the motor shell heat dissipation, therefore, the wind turbine heat dissipation condition is poor. In Tibet, the sunshine time is long and the radiation is strong. The direct sunlight on the metal shell of the engine room increases the air temperature in the engine room, affects the heat dissipation of the motor and accelerates the aging of the parts.

Solution: considering the insulation grade of high temperature resistance of generator, higher grade insulation material should be selected.

4. Prospect of wind power generation in Tibet

Tibet is rich in wind energy resources, which was developed earlier. Through the implementation of a series of projects, Tibet has accumulated a lot of experience and human resources, and has the resource conditions and technical ability to develop wind energy resources. Moreover, wind power generation is the focus of renewable energy technology development in Tibet during the 12th Five Year Plan period, and it is also one of the main measures to solve the current contradiction of power shortage in Tibet. Therefore, the development and utilization of wind energy resources in our district can not only play an important role in meeting the energy supply, protecting the living environment, solving the problem of electricity consumption in remote, agricultural and pastoral areas, and getting rid of poverty; It can promote the economic development of economic regions, especially the development of agriculture and animal husbandry. Therefore, it is particularly important to carry out wind power demonstration sites in Tibet[5].

Considering that the current wind power technology is still difficult to solve the problem of unstable output power of wind power, and the impact of wind energy resources on wind power generation in our region, it is suggested to solve the power consumption problem of farmers and herdsmen in remote areas where the grid is not easy to reach mainly through independent

small and medium-sized wind power system or wind solar complementary power generation system. As long as we make full use of the accumulated experience of technicians in long-term project implementation, building photovoltaic power stations or wind solar complementary power stations in alpine and high-altitude areas, and rationally use a large number of management, operation and maintenance personnel, we will promote the development and utilization of wind energy resources in Tibet. Through the implementation of a number of projects, we will find a way suitable for the utilization of wind energy in Tibet, Speed up the development and application of wind power in Tibet, and provide data analysis and scientific basis for the next demonstration and promotion of large and medium-sized wind farms and wind solar hybrid power stations in Tibet.

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