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An Empirical Study on Wind-solar Energy Reserve in Inner Mongolia in the Context of Carbon Neutrality

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Abstract:
This study explores the empirical research of wind and solar energy reserves in the Inner Mongolia region within the broader context of carbon neutrality. Through detailed surveys and data analysis of wind and solar energy resources, we comprehensively assess their potential, reserves, and sustainability. Our findings reveal Inner Mongolia's abundant wind and solar resources, pivotal in advancing carbon neutrality strategies. However, overcoming challenges such as cost, efficiency, sustainability, and grid coordination of energy storage technologies is imperative to fully leverage this potential. Therefore, this paper proposes suggestions for improvement, including technological innovation, planning optimization, and energy coordination measures. These recommendations aim to address current challenges and enhance the utilization of wind and solar resources in Inner Mongolia, providing valuable insights for future energy planning and policy formulation. This study is a guiding framework for promoting sustainable energy development in the region.
Keywords: carbon neutrality, wind energy, light energy, reserve, Inner Mongolia region

1. Introduction

In 2020, China unveiled ambitious targets in its fight against climate change: aiming to reach the carbon dioxide emissions peak by 2030 and striving for carbon neutrality by 2060. These targets signify China's steadfast commitment to addressing the escalating challenges posed by climate change and positioning itself as a global leader advocating carbon neutrality.

Amidst this ambitious endeavor, the Inner Mongolia region emerges as a crucial protagonist due to its vast expanse characterized by extensive grasslands, deserts, and abundant wind energy resources. Renowned as one of China's premier regions with significant wind energy potential, Inner Mongolia also boasts ample sunlight, particularly in its desert areas, where solar radiation is abundant and the duration of sunshine is prolonged.

Establishing these dual carbon goals has spurred significant advancements in clean energy technologies, particularly solar and wind power. However, despite these notable strides, developmental hurdles persist. Chief among these concerns is the inherent variability associated with renewable energy sources. This variability underscores the urgent need to address energy supply instability, ensuring a reliable and sustainable energy landscape for the future.

The integration of wind and solar energy, storage technologies, and electricity network planning presents a promising avenue for Inner Mongolia to advance towards carbon neutrality. Simultaneously, combining the local electricity consumption data and the conversion rates of solar and wind energy in Inner Mongolia, reasonable electricity generation levels can be calculated through modeling, thereby maximizing the utilization of limited resources. As nations worldwide shift their development focus from rapid increase towards sustainability, the importance of renewable energy has become increasingly apparent. Transitioning from traditional energy sources to clean alternatives is now recognized as a pragmatic necessity. In this context, considering the transition from traditional energy to clean energy as merely a symbolic commitment is no longer sufficient; concrete and feasible actions must be taken. In the case of Inner Mongolia, the development and utilization of wind energy resources emerge as key components of its sustainability strategy. Beyond meeting national carbon reduction targets, these efforts ensure the region's continued prosperity and development. By embracing clean energy initiatives, Inner Mongolia contributes to global efforts in combating climate change and sets a precedent for responsible environmental stewardship and economic growth. In essence, adopting clean energy technologies in Inner Mongolia represents a tangible step towards realizing the objectives outlined in the dual carbon plan. It underscores the region's commitment to practical action to provide viable pathways for sustainable development locally and nationally. Through these initiatives, Inner Mongolia is poised to lead by example, paving the way for a greener, more sustainable future for itself and the broader region.

This paper will conduct a literature review on solar and wind energy studies, respectively. Firstly, regarding solar energy research, Inner Mongolia Science and Technology investigated the resource situation in Inner Mongolia, collecting data on the terrain, topography, and duration of sunshine in the region. Utilizing data collection methods, they obtained the average annual sunshine duration and radiation in Inner Mongolia, demonstrating the region's abundant solar energy resources and development potential [1]. Zhang Fenglan et al. found the issues, such as the low utilization rate of solar power generation equipment, the electricity generation falling below-installed capacity, the total number of generators far exceeding the total electricity consumption, and high land taxes, etc. The author proposed methods to slow the installation speed of photovoltaic power generation and reduce low-tax revenues. They also collected data on the installed capacity of photovoltaic power generation in Inner Mongolia, the average annual electricity consumption, and land taxes. They concluded that Inner Mongolia needs to address the urgent issue of dual certificates for using the same land and halt the process of undeveloped photovoltaic power generation projects to avoid unnecessary construction [2]. Wen Jianliang studied the potential issues facing photovoltaic power generation projects in Inner Mongolia: the concentration of photovoltaic power generation projects among two large enterprises leaves little room for survival for small enterprises, which could encounter difficulties in financing and low profits. He also collected business data from small and medium-sized photovoltaic power generation enterprises in Inner Mongolia. He concluded that national coordination among enterprises is needed for progress in the rapidly developing new energy field [3]. Jin Shiwen suggested that the reduced government subsidies and high generation costs are the problems for photovoltaic power generation. In this study, he collected data on subsidies for photovoltaic power generation in Inner Mongolia in recent years and the costs of photovoltaic power generation, concluding that if photovoltaic power generation is to achieve sustainable development in Inner Mongolia, attention must be paid to land taxes and government subsidies [4]. Fu Dongmei suggested that insufficient market demand is poised to be the biggest barrier to photovoltaic power generation in Inner Mongolia. She proposed methods to increase domestic market expansion and broaden international markets. She collected data on the total solar energy generation in Inner Mongolia in recent years and concluded that to increase solar energy production in Inner Mongolia, the market must be explored in advance [5].
The subsequent focus lies on research about wind energy. Li Quanzhu et al. researched the current status of wind energy resources in Inner Mongolia. They gathered data on the region's installed capacity and annual electricity generation of wind power equipment. They suggested that Inner Mongolia's wind energy development needs to enhance its autonomy, while government subsidies should be provided to ensure the sustainability of enterprises [6]. Wu Yue investigated the maximum power generation of wind turbines and proposed methods to maximize wind energy utilization by altering traditional turbine tip speeds. Their calculation estimated the best blade model and tip speed, which offered insights into optimizing wind turbine performance [7]. Hou Guoqing mentioned the challenges wind energy generation faces in Inner Mongolia, such as insufficient independent innovation and the prevalent use of foreign equipment for wind turbines. By gathering information on the number of wind turbines in Inner Mongolia and the proportion of foreign machinery, the author concluded that enhancing domestic research and development capabilities is essential for reducing wind power generation costs [8]. Liu Shuxiang explored the reasons behind the bottleneck in wind energy generation in Inner Mongolia, highlighting the dominance of energy-intensive industries, limited financing, and experts for clean energy industries. The author proposed that government intervention is necessary to adjust resource allocation, which should increase the investment in clean energy industries to encourage innovation and development [9].

In conclusion, current research was primarily focused on individual sectors of clean energy, such as solar or wind energy analysis. However, more comprehensive research on the overall clean energy reserves and development in Inner Mongolia is still required. Therefore, this paper aims to thoroughly examine and analyze the clean energy reserves in Inner Mongolia while addressing issues related to its development and planning. Through systematic research, Inner Mongolia's potential in the clean energy field and the challenges will be discussed in depth. This holds practical application value for local governments in achieving overall carbon neutrality goals but also aids in formulating effective strategies and plans for sustainable development in the region. The research aims to provide a comprehensive perspective to facilitate the growth of clean energy in Inner Mongolia and the achievement of carbon neutrality and sustainable development.

2. Analysis of Clean Energy Reserve in Inner Mongolia

This section will examine the natural resource conditions in Inner Mongolia, focusing on wind and solar energy resources. First, the data of average wind speeds and wind energy densities from various regions of Inner Mongolia was collected and compared to select the areas with the highest development potential. Second, the data on solar energy reserves in different areas of Inner Mongolia was adopted. With the average annual sunshine duration and effective sunshine duration, the primary regions for solar energy development were revealed.

2.1 Reserve status of wind energy resources in Inner Mongolia (in terms of time and location)

Table 2.1 Main Wind Energy Data of Cities in Inner Mongolia

	Annual average wind speed	Annual average wind speed at 100m	Average wind energy density
Hohhot	2.5 m/s	6.0 m/s	300-350W/m2
Baotou	3.1 m/s	6.1 m/s	300-350W/m2
Wuhai	3.3 m/s	6.3 m/s	300-350W/m2
Chifeng	3.9 m/s	5.8 m/s	300-350W/m2
Tongliao	3.5 m/s	6.0 m/s	300-350W/m2
Erdos	3.5 m/s	6.2 m/s	350-400W/m2
Hulunbeir	4.0 m/s	6.1 m/s	350-400W/m2
Bayannur	2.6 m/s	6.2 m/s	350-400W/m2
Ulanchab	2.6 m/s	6.0 m/s	350-400W/m2
Xing'an League	3.7 m/s	6.2 m/s	400-450W/m2
Xilingol	3.7 m/s	6.3 m/s	400-450W/m2
Alexa league	4.7 m/s	6.3 m/s	400-450W/m2

Hohhot, Baotou, Wuhai, Chifeng, and Tongliao regions exhibit relatively consistent wind energy resources. The annual average wind speeds at a height of 100 meters in these areas range from 5.8 to 6.3 meters per second, indicating relatively stable wind conditions. Additionally, these regions' average wind energy densities range from 300 to 350 watts per square meter, suggesting considerable potential for wind energy resources.

In Ordos, Hulunbuir, Bayannur, and Ulanqab, the annual average wind speeds at the height of 100 meters range from 6.0 to 6.2 meters per second, with average wind energy densities of approximately 350-400 watts per square meter.

In Xing'an League, Xilin Gol League, and Alxa League, the annual average wind speeds at the height of 100 meters range from 6.2 to 6.3 meters per second, with average wind energy densities of approximately 400-450 watts per square meter.

Across Inner Mongolia's annual average wind speeds are above 3 meters per second, gradually increasing from east to west. For instance, in the northern part of Ulanqab and the western part of Xilin Gol League, wind speeds reach around 5 meters per second. In contrast, in areas such as the Greater Khingan Range, Chifeng Basin, Hetao Plain, and the southern part of Ulanqab, wind speeds generally remain below 3 meters per second. Hohhot has an average wind speed of 1.8 meters per second.

The number of days with threshold wind velocity at or above three meters per second varies across different regions. For instance, Hulunbuir experiences over 180 days, Xilin Gol League over 240 days, the northern part of Ulanqab around 280 days, Chifeng and Tongliao over 200 days, the northern part of Bayannur over 260 days, Ordos over 130 days, and Hohhot, Baotou, the Hetao Plain, and the Hetao Plain for 70-80 days.

In summary, most Inner Mongolia Autonomous Region regions possess moderate to high wind energy resources. However, it is essential to highlight that regions such as Xing'an League, Xilin Gol League, and Alxa League have richer wind energy resources, exhibiting higher annual average wind speeds and wind energy densities.

The Inner Mongolian wind energy resource reserve demonstrates advantages as follows:

a. High wind speed areas: Inner Mongolia has several high wind speed areas, such as the Hulunbuir grasslands and the Alxa Desert, where wind speeds are often high, making them highly suitable for wind power generation. These high wind speed areas can provide more abundant and stable wind energy resources, facilitating the performance of wind turbines in generating electricity.

b. Wind speeds in Inner Mongolia are significantly influenced by seasonal variations, with noticeable differences between the four seasons. Generally, wind speeds are relatively stable and mild in summer, while they exhibit higher levels during winter. This seasonal variation has important implications for wind power projects in Inner Mongolia. These seasonal changes must be fully considered when planning and implementing wind power projects. This involves selecting appropriate types of wind turbines and farm layouts to ensure efficient electricity generation throughout the year. Additionally, intelligent control systems need to be employed to adjust the operation strategies of wind power systems according to seasonal variations in wind speed, thereby ensuring system reliability and stability.

c. Terrain and topography: The terrain and topography of Inner Mongolia also affect wind speeds. Large plain areas, open grasslands, and desert regions typically have higher wind speeds, while mountainous or hilly terrain may result in lower wind speeds due to topographical obstruction.

In summary, wind energy resources in Inner Mongolia are conducive to wind power generation.

2.2 Reserve status of solar energy resources in Inner Mongolia

According to the data in Figure 2.1, it is evident that the annual sunshine duration in various regions of Inner Mongolia exceeds 2700 hours, ranking second only to Tibet nationwide. Particularly noteworthy are the western regions, such as Bayannur and Alxa League, which boast sunshine durations exceeding 3000 hours annually. This establishes a solid foundation for developing solar power generation in Inner Mongolia.

From Table 2.2, it is evident that in recent years, most regions of Inner Mongolia have had available sunlight hours exceeding 1400 hours, with the highest average utilization hours observed in Xilin Gol reaching 1684 hours, followed closely by Alxa League, Bayannur, and Ulanqab. However, the annual utilization hours in various regions of Inner Mongolia are unstable, showing significant fluctuations. For instance, from 2016 to 2017, Xilin Gol saw an increase of 162 hours, Alxa League increased by 155 hours, Ordos increased by 249 hours, Bayannur increased by 172 hours, Baotou increased by 93 hours, Wuhai increased by 161 hours, Hohhot increased by 95 hours, and Ulanqab increased by 171 hours. From 2017 to 2018, Alxa League decreased by 13 hours, Bayannur decreased by 14 hours, Baotou increased by 111 hours, Ordos decreased by 40 hours, Wuhai increased by 65 hours, Hohhot increased by 56 hours, Ulanqab increased by 128 hours, and Xilin Gol increased by 37 hours. The significant fluctuations in available sunlight hours pose challenges to developing solar energy resources in Inner Mongolia.

Figure 2.1 Annual sunshine duration of the cities in Inner Mongolia

Table 2.2 2016~2018 The solar utilization in various regions of Inner Mongolia (hour)

	2016	2017	2018	Average Utilization Hours
Alexa league	1487	1638	1625	1583
Bayannur	1455	1627	1613	1565
Baotou	1453	1546	1657	1552
Erdos	1346	1595	1555	1498
Wuhai	1362	1523	1588	1491
Hohhot	1400	1495	1551	1482
Ulanchab	1475	1646	1574	1565
Xilingol	1564	1726	1763	1684

The development of solar power generation in Inner Mongolia has the following advantages:

a. Abundant Solar Resources: Inner Mongolia enjoys relatively long sunshine durations and high annual average sunlight hours, indicating abundant solar resources in the region and providing ample energy sources for solar energy reserves.
b. Superior Geographic Conditions: Due to its high altitude and few mountains, most areas of Inner Mongolia have high levels of solar radiation intensity and unobstructed geographic conditions. These geographic conditions endow Inner Mongolia with significant solar energy reserve potential.
c. Solar Energy Storage Technologies: Solar energy storage technologies primarily include solar thermal storage (STS) and photovoltaic (PV) energy storage. Inner Mongolia is suitable for developing STS, which utilizes solar energy to store thermal energy for heating or power generation. Additionally, Inner Mongolia is also conducive to developing PV technology, which converts solar energy into electricity for storage and utilization.
d. Advantages in Land Resources: Inner Mongolia has abundant land resources, with vast undeveloped land available to construct solar energy reserve projects. Sufficient land resources provide favorable development space for solar energy reserves.
e. Comprehensive Development of Clean Energy: The development of clean energy has become one of the crucial directions for national development. As an important form of clean energy, solar energy reserves have promising development prospects. With proactive government policy support and substantial investment direction, the rapid development of solar energy reserves in Inner Mongolia will be greatly promoted.
In summary, Inner Mongolia possesses abundant solar resources, favorable geographical conditions, and vast land resources, providing a solid foundation for developing solar energy reserves. The application of STS and PV power generation technologies holds the potential to effectively harness these solar energy resources, promoting the development of clean energy and facilitating the transformation of the energy structure. The government's proactive support and financial investment will further accelerate the development of solar energy reserves in Inner Mongolia, contributing significantly to realizing sustainable energy utilization and the nation's carbon neutrality goals.

3. Development status of wind and solar energy

3.1 Current status of installed capacity

By the end of 2021, the installed capacity of wind power in Inner Mongolia had reached an impressive 39,960 megawatts (MW), a figure that underscores the significant position and influence of Inner Mongolia in the field of wind power generation and highlights China's steadfast commitment to clean and renewable energy. Wind power, as a clean and sustainable energy form, holds paramount importance for environmental preservation and the country's energy structure adjustment and green development objectives.
Inner Mongolia, China's largest provincial-level administrative region, possesses abundant wind energy resources, providing ample room for the development of wind power generation. According to relevant data, Inner Mongolia's wind power installed capacity has exceeded 120,000 MW, with over 3,000 MW of new wind power capacity added in 2019 alone, showcasing the rapid growth momentum of the wind power industry in Inner Mongolia. This substantial wind power installed capacity reflects Inner Mongolia's formidable strength in wind power generation and consolidates its leading position in China's clean energy sector. As a clean and renewable energy form, wind power generation plays a crucial role in reducing carbon emissions, improving air quality, and driving sustainable energy transformation.
Regarding policy support, the national government's vigorous backing and encouragement for clean energy are strong driving forces for developing Inner Mongolia's wind power generation industry. Moreover, the Inner Mongolia Autonomous Region government is actively committed to promoting the robust development of the wind power generation industry, formulating policies and plans to support this industry. According to the "14th Five-Year Plan for Renewable Energy Development in Inner Mongolia Autonomous Region," a large-scale renewable energy development plan will be implemented during the 14th Five-Year Plan period. As per the plan, the region aims to add over 80,000 MW of new renewable energy installed capacity, including wind power installed capacity reaching 89,000 MW. This ambitious target signifies that by 2030, the new energy installed capacity in Inner Mongolia will surpass 0.2 million MW, while the total new energy generation will surpass traditional thermal power generation.
In conclusion, the prospects for wind power generation capacity in Inner Mongolia are promising, with even greater development potential in the future. With continuous technological advancements and sustained policy support, Inner Mongolia's wind power generation industry will continue its rapid development momentum, making a more significant contribution to China's energy transition and green development endeavors. The development in this field helps reduce carbon emissions and provides a solid foundation for the sustainable development of the region and the country. The efforts of Inner Mongolia in

terms of clean energy will yield positive impacts in the future, promoting a more environmentally friendly and sustainable future.

Table 3.1 The installed wind power capacity in various regions of Inner Mongolia in 2021 (unit: megawatts)

	Installed capacity		Installed capacity
Hohhot	Approx. 3000	Hulunbeir	Approx. 1500
Baotou	Approx. 2500	Bayannur	Approx. 800
Wuhai	Approx. 400	Ulanchab	Approx. 2000
Chifeng	Approx. 3500	Xing'an League	approx. 1000
Tongliao	Approx. 500	Xilingol	approx. 300
Erdos	Approx. 6000	Alxa league	Approx. 800

3.2 The wind energy reserve calculation model

This section will establish a wind energy reserve calculation model. The specific wind energy reserve calculation model will provide necessary parameter explanations at the start. Finally, calculations will be conducted for five common wind turbines.
Parameter Description:
S: Land area of Inner Mongolia.
m: Number of wind turbine types.
i: Denotes the i th wind turbine type, where ;
s: Land area occupied by the i th wind turbine type;
e: Power generation capacity of the i th wind turbine type (in 10 megawatts, MW);
α The utilization coefficient of wind energy is .
Wind Energy Reserve Calculation Model:
This paper identified the five common types of wind turbines in Inner Mongolia. The following section will provide calculations for each of these five types of wind turbines.
a. Goldwind GW140/2500:
- Maximum reserve upper limit:
- Land area: approximately 7854 m²
- Power generation capacity: 25kWh, where
- The cost required for a single power generation site is $4 million, where .
b. Mingyang MY3.0-135:
- Maximum reserve upper limit:
- Land area: approximately 8100 m²
- Power generation capacity: 30kWh, where $0 < \alpha \leq 1$
- Cost at maximum reserve upper limit:
- The cost required for a single power generation site is $3.5 million, where $0 < \alpha \leq 1$
c. Envision EN148-4.5MW:
- Maximum reserve upper limit:
- Land area: approximately 10000 m²
- Power generation capacity: 45kWh, where
- Cost at maximum reserve upper limit:
- The cost required for a single power generation site is $6 million, where
d. DEC D116-2.5MW:
- Maximum reserve upper limit:
- Land area: approximately 8000 m²
- Power generation capacity: 25kWh, where
- Cost at maximum reserve upper limit
- The cost required for a single power generation site is $3.5 million, where
e. Sinovel SL3000/93:
- Maximum reserve upper limit:
- Land area: approximately 8500 m²
- Power generation capacity: 30kWh, where $0 < \alpha \leq 1$
- Cost at maximum reserve upper limit:
- The cost required for a single power generation site is $5 million, where

3.3 Solar Energy Storage Calculation Model

As a northern province of China, Inner Mongolia possesses abundant solar energy resources, exhibiting significant potential for photovoltaic (PV) power generation. With technological advancements and policy support, the prospects for solar energy generation in Inner Mongolia are promising.
Firstly, Inner Mongolia enjoys prolonged sunshine duration and high radiation intensity, which is conducive to the efficiency of solar photovoltaic panels. Secondly, Inner Mongolia's vast geographical expanse and extensive desertification areas provide ample territory for constructing large-scale solar power plants. Additionally, the government's increasing support for renewable energy serves as policy assurance for solar energy generation in Inner Mongolia.
According to existing data, Inner Mongolia's current installed photovoltaics capacity has exceeded 17 million

kilowatts, ranking among the top in the country. However, predicting the maximum installed capacity of solar energy generation in Inner Mongolia requires consideration of various factors such as land resources, environmental conditions, technological levels, and grid construction. Considering these factors comprehensively, it is estimated that the maximum installed solar energy generation capacity in Inner Mongolia could exceed 20 million kilowatts.

To achieve this goal, measures need to be taken in various aspects. Firstly, technological innovation is crucial, particularly in solar photovoltaic panels. Continuously improving the conversion efficiency of solar panels and reducing production costs can enhance the competitiveness and feasibility of solar energy generation. Additionally, promoting research and development of new solar technologies, such as thin-film solar cells and multi-junction solar cells, can enhance the performance of solar energy generation systems. Secondly, grid construction and renovation are also essential, with policy support and market mechanisms being crucial. The government can provide incentives such as subsidies and reward programs to encourage the development of solar energy generation. Furthermore, establishing market mechanisms such as renewable energy certificate systems and carbon emission trading markets can provide more commercial opportunities for solar energy generation projects. By comprehensively implementing these measures, solar energy generation in Inner Mongolia is expected to play a greater role in the future, making significant contributions to sustainable development and the transition to green energy. This will help reduce carbon emissions, alleviate energy supply and demand pressures, and promote the widespread application of clean energy.

Solar Energy Storage Upper Limit:

This section will construct a solar energy reserve calculation model, providing necessary parameter specifications and a detailed calculation model.

S: Land area of Inner Mongolia.

m: Type and quantity of solar generator.

i: The ith type of solar generator, ;

si: Individual footprint area of the ith type of solar generator;

ei: Generation power of the ith type of solar generator. (in watts);

α: Available area coefficient of solar power generation, where ;

a. Polycrystalline Silicon Photovoltaic Power Generation System:

- Canadian Solar CS6K-300MS
- maximum storage upper limit,
- Individual footprint area: approximately 600 m², with a power output of 300 watts.
- Cost: , with a unit cost of approximately $900 US dollars.

b. Thin-Film Photovoltaic Power Generation System (First Solar Series 6):

- Maximum storage upper limit:
- Individual footprint area: approximately 1,300 m², with a power output of 430 watts.
- Cost: with a unit cost of approximately $800 US dollars.

3.4 Development planning proposals

The proportion of land required to reach the current installed capacity: According to the data in Table 3.3, the average land requirement for different models of wind energy equipment is 0.9634%, with a minimum value of 0.7506% and a maximum value of 1.1226%.

Cost requirement: Based on the data in Table 3.3, the average cost requirement for different models of wind energy equipment is 5.7955× 108 CNY, with a minimum value of 4.6619× 108 yuan and a maximum value of 6.76361× 108 CNY.

Maximum installed capacity under current wind energy land development level: According to the data in Table 3.3, the average maximum installed capacity of different models of wind energy equipment under the current wind energy land development level is 54.2086 million kilowatt-hours, with a minimum value of 46.9503 million kilowatt-hours and a maximum value of 67.6085 million kilowatt-hours.

Land proportion: Based on the data analysis in Table 3.3, the Goldwind GW140/2500 model has the highest land proportion, reaching 1.1226%, while the Envision EN148-4.5MW model has the lowest land proportion, at 0.7506%. If land resources are limited, priority can be given to the Envision EN148-4.5MW model as it requires less land.

Cost: Based on the data analysis in Table 3.3, there is a significant difference in the cost of different models of wind energy equipment. The Mingyang MY3.0-135 model has the lowest cost, at 4.6619× 108 CNY, while the Sinovel SL3000/93 model has the highest cost, at 6.63106× 108 CNY. The Mingyang MY3.0-135 model can be considered if budget constraints are a concern.

Maximum installed capacity: According to the data analysis, the Envision EN148-4.5MW model has the highest maximum installed capacity under the current wind energy land development level, reaching 67.6085 million kilowatt-hours, while the DEC D116-2.5MW model has the lowest maximum installed capacity, at 46.9503 million kilowatt-hours. If aiming for a higher installed capacity, the Envision EN148-4.5MW model can be considered.

Table 3.3 Analysis of installed capacity of wind energy in Inner Mongolia

	Proportion of land required to reach current installed capacity	Required cost(CNY)	Maximum installed capacity at current wind energy land development level (10,000 kWh)
Goldwind GW140/2500	1.1226%	6.76361×10^8	4782.31
Mingyang MY3.0-135	0.912%	4.6619×10^8	5564.48
EnvisionEN148-4.5MW	0.7506%	5.32776×10^8	6760.85
DEC D116-2.5MW	1.0809%	5.59433×10^8	4695.03
Sinovel SL3000/93	0.9529%	6.63106×10^8	5302.62

4. Summary

This study investigates the feasibility and potential of Inner Mongolia's wind and solar energy reserves against carbon neutrality. Through an in-depth analysis and assessment of the abundant wind and solar energy resources in Inner Mongolia, it was found that the region boasts superior natural conditions and potential, providing a solid foundation for the development of wind and solar energy.

Firstly, the assessment of wind energy resources in Inner Mongolia revealed abundance, particularly in its grassland and desert areas. These wind resources exhibit enormous potential, offering highly favorable conditions for developing clean energy. Secondly, evaluating solar energy resources indicated that the region benefits from favorable natural conditions characterized by long hours of sunlight and high radiation intensity, making it highly suitable for solar power generation. These advantageous meteorological conditions provide significant potential for solar power generation. Furthermore, mathematical models estimated the maximum installed capacity of wind energy in Inner Mongolia. This calculation aids in maximizing the utilization of renewable energy resources in Inner Mongolia, ensuring efficient utilization of clean energy resources and minimizing waste. Scientific modeling and precise data analysis enable better planning and optimization of wind power projects to meet energy demands, reduce costs, minimize resource waste, and enhance the stability and reliability of the energy system.

In conclusion, Inner Mongolia possesses abundant wind and solar energy resources, making the development of wind and solar energy crucial for attaining carbon neutrality goals. Investment and development in wind power generation, photovoltaic power generation, and energy storage technologies can sustainably utilize wind and solar energy reserves in Inner Mongolia, providing a clean and reliable energy supply for economic development. This not only aids in reducing carbon emissions but also promotes optimization of the energy structure, facilitating the realization of sustainable development and green energy transition. Clean energy development in Inner Mongolia will significantly contribute to national carbon reduction and sustainable development goals.

REFERENCES

[1].Light Energy Resources in Inner Mongolia[J].Inner Mongolia Science and Technology, 1982(02):56.

[2] Zhang Fenglan, Li Zhihua, Wang Peixin. Problems and Countermeasures of Photovoltaic Power Generation in Inner Mongolia [J]. Northern Economy, 2019(06):49-5 3.

[3] Wen Jianliang. "Hidden Worry" Behind the Glory of Inner Mongolia Photovoltaic Industry [J]. Northern Economy, 2015(02):45-47.

[4] Jin Shiwen. Current Situation and Problems of Photovoltaic Power Generation in Inner Mongolia [J]. Science and Technology and Economy of Inner Mongolia, 2017(17):21+48.

[5] Fu Dongmei. Main factors and construction ideas affecting the development of the photovoltaic industry in Inner Mongolia [J]. Northern Economy, 2012(11): 34-35.

[6] Li Quanzhu, Sheng Yinghui, Bao Tana. Analysis of Advantages and Development and Utilization of Wind Energy Resources in Inner Mongolia [J]. Northern Economy, 2008 (10): 59-60.

[7]Yue Wu.Discussion on Problems and Solutions of Wind Power Generation from Electric Power Development in Inner Mongolia[J]. Journal of Inner Mongolia University of Technology (Natural Science Edition), 2016,35(01):31-34. DOI:10.13785/j.cnki.nmggydxxbzrkxb.2016.01.006.

[8]Guoqing Hou.Present Situation and Prospect of Wind Power Generation in Inner Mongolia[J].power survey and design, 2004(03): 77-80.

[9]Liu Shuxiang.Current Situation and Existing Problems

of Energy Economic Development in Inner Mongolia under New Normal[J].Journal of Inner Mongolia University for Nationalities(Social Science Edition), 2018, 44(03):83-