More Wind Power to Enable Green Development of China

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Abstract

The development of renewable energy has become a core component of energy transformation of all countries worldwide and an important way to deal with climate change. Due to China's huge power demand, rapidly developing equipment manufacturing, and the national strategic guidance of green development, both the newly installed renewable energy and the accumulated capacity of renewable energy in China have ranked first in the world in recent years. In 2018, renewable energy power generation amounted to 1.87 trillion kWh, accounting for 26.7 % of total power generation, in which wind power was 366 billion kWh, accounting for 5.2% of total power generation, up four percentage points as compared with 2017. During the Twelfth Five-Year Plan period of China, wind power became the third largest power source after thermal power and hydropower. According to the Chinese Wind Power Development Plan during Thirteenth Five-Year Plan, the national annual generating capacity of wind power will reach 420 billion kWh by 2020, accounting for about 6% of the country's total power generating capacity, making wind power an important enabler to achieve the goal that non-fossil fuels in China's primary energy consumption will take up 15% by 2020.

China’s wind power equipment manufacturing has been improved continuously with wind turbine costs reduced significantly. In a short period of time, China has rapidly developed into the world’s largest wind power market where both manufacturing and technology accumulation have achieved qualitative and quantitative breakthroughs. Wind turbines made in China has also started to enter the international markets. Alongside the rapid development of the Chinese wind energy market, however, curtailment of wind power had become a major issue that has not been effectively alleviated until the most recent years. In 2018, the rate of wind power curtailment dropped to 7%, an improvement of 5 percentage points year-on-year. With the promotion of the national "grid parity" policy and the global roll-out of wind power auction policies, it is foreseeable that in the next 2-3 years, renewable energy in China will achieve grid parity, and even become the most economical and reliable form of energy.

The development of renewable energy is indispensable from government policy support, including subsidies, which is a common phenomenon around the world. With grid parity approaching, gradual withdrawal of subsidies is a trend, but how to ensure that after the subsidy exits, the wind power market can continue to develop, the enterprises in the industry can develop healthily and sustainably, or mergers and acquisitions can take place in an orderly manner, all these affecting the confidence of the wind industry and enterprises in green development moving forward. In addition, the development of renewable energy is inseparable from market-oriented guidance in its real sense. At present, traditional energy still occupies the majority of the energy system of China. The implementation of renewable energy policy is not fully in line with market expectation, and policy implementations vary from one place to another. Therefore, a clear set of policy

implementation details and an effective mechanism to supervise policy implementation are needed in order to further promote renewable energy development, break the old interest pattern and remove local obstacles.

In addition to policy guidance, the development and utilization of wind power fundamentally depends on technological innovation and progress. Medium and low-speed wind turbines, decentralized applications, and the accelerated offshore wind power development can only be made possible with technological advancement and a further improvement of the industrial chain, to ensure the economy, reliability and safety of larger-size wind turbines.

At present, despite some “anti-globalization” voices and occurrences in the world, the global challenges confronted by human development, including energy security and climate change, require the joint efforts of governments, academics, and industry to come up with innovative solutions to ensure sustainable development. Enterprises, acting as the main practitioner of innovation, should strengthen global cooperation and technology exchanges, and achieve sustainable development out of healthy competition.

The report of the 19th National Congress of the Communist Party of China once again stressed that China should "promote the energy production and consumption revolution and build a clean, low-carbon, safe and efficient energy system". The unceasing sophistication of technologies in renewable energy sector has driven the transformation of the global energy system. China is both a major energy producer and a major consumer. While committed to achieving its energy development goals at home, China will also contribute to the global energy system transformation. As a large global-leading renewable energy company, Siemens

Gamesa Renewable Energy hopes to share with the Chinese government and partners our technologies, ideas, insights and project implementation experience accumulated across the globe through this report. We also expect to work closely with Chinese partners to jointly explore the wind energy market and potential in China and the world, and support the Chinese people to live a happy future of green development.

This report is composed of four parts. The first part introduces the development trend of wind power in the world, and the irreplaceable role of wind power in China's future green growth of energy; the second part analyzes the current challenges faced by Chinese wind power market; the third part puts forward some policy recommendations for the sustainable development of the wind power industry in China; the fourth part is a conclusion of the full paper.

I. Wind power to continue an irreplaceable role in China's green growth of energy

i. The global wind energy market is in the ascendant

Global energy demand continues to grow rapidly driven by the growing global economy and the electrification of energy consumption in emerging areas such as transportation and heating. The International Energy Agency forecasted that the global power generation additions until 2040 will exceed total existing installed base[i]. Moreover, in face of many global challenges such as climate change and traditional fossil-oil energy depletion, countries around the world are making great efforts to transform into a green development model to reduce

carbon dioxide emissions and achieve balanced economic and environmental development. In Europe, Netherlands, Spain, United Kingdom, and Germany plan to abandon the use of coal to generate electricity by 2025-2030. As an important driver for green and sustainable development of the global economy, many countries in the world have taken clean renewable energy development as a common direction of their energy strategy adjustment.

Wind power is a kind of clean and renewable energy. Thanks to continuous progress in the design and manufacture of large wind turbines, continuously improved reliability of wind power equipment, innovation of tools and technologies for wind farm operation and maintenance, coupled by various governments implementing wind power auction systems, the levelized cost of energy (LCOE) of wind power is decreasing, and wind energy has become the most competitive energy source in some areas. According to International Renewable Energy Agency (IRENA), the global weighted average cost of electricity from onshore wind fell by 23% between 2010 and 2017, to around USD 0.06/kWh, with some projects regularly delivering electricity for just USD 0.04/kWh. Recent auctions in Brazil, Canada, Germany, India, Mexico and Morocco have resulted in onshore wind power LCOE as low as USD 0.03/kWh[ii].

According to WindEurope, wind energy surpassed hydropower to become the third largest source of electricity in 2015 in Europe, next only to natural gas and coal, and took a step further to overtake coal as the second largest source of electricity in 2016. According to International Energy Agency, the newly installed capacity of renewable power generation in 2015 exceeded the installed capacity of

conventional power generation for the first time, indicating that the global power installation was undergoing structural changes.

Looking ahead, the development of the global wind power industry will show the following trends:

1. Technological advancements lifting the rating power of wind turbines and improving the utilization and economy of wind resources. The rating power of wind turbine generators has evolved from the original tens of kilowatts to today's 5MW of an onshore wind turbine and 10MW of an offshore wind turbine, with rotor diameter soaring to nearly 200 meters, and the highest tower installed in Asia up to 153 meters. This large-scale trend is continuing. The increase in the size of the wind turbine also means higher quality demand on components manufacturing, and adds to the difficulty of turbine transportation. All these requirements will lead to an increase in the construction cost of the wind farm. However, as long as the blade sweeping area is increased, more benefits can be generated. Provided that overall safety performance of a wind turbine is tested rigorously, larger wind turbines will continue to emerge. The final deciding factor for the turbine size will be the balance between the total investment and the wind power generated. In this process, technology and R&D will play a vital role.

2. In the digital age, wind turbines and wind farms will be smarter. Sensors have been used in wind turbines for more than 10 years to monitor and collect data with regard to energy output and weather conditions. Nowadays, the problem confronted by the wind power industry is how to transform the big and increasing data into decision-making insights, in order to make the design and manufacturing of wind turbines and operation and maintenance of wind farms more intelligent

and efficient. Big data could also be utilized to reduce the need for on-site maintenance by personnel and thus reducing safety risks. The remote diagnostic centers of Siemens Gamesa in Denmark and Spain monitor the operation of 28,000 wind turbines worldwide, collects more than 200 GB of data per day from numerous sensors, and can resolve more than 85% of problems remotely through data analysis. 98% of critical component failure may be detected in advance. By performing 7x24 remote monitoring and alarm management, wind turbine onsite maintenance can be reduced by more than 2000 times per month. While helping wind farm investors to more accurately design investment analysis model for future projects, these data and operation and maintenance experience could also assist governments to make reasonable decisions on the level of subsidies for given projects.

3. The advancement of energy storage technology will effectively promote the comprehensive development and utilization of wind energy. Renewable energy is intermittent. Due to the instability of wind power production and supply, the development of energy storage technology will help resolve the issue and promote the comprehensive utilization of wind and solar energy, while reducing the disturbance to the grid. High-performance energy storage projects have been developed in Australia and Germany. The German Federal Ministry for Economic Affairs and Energy funded the development of Electric Thermal Energy Storage (ETES) technology since 2014, which can store excess power on the grid in stones, enabling its temperature up to 600-800 ℃. This heat can be converted into electric energy by conventional steam power generation when energy supply is insufficient. The technology is very economical and is one-tenth the cost of traditional battery energy storage technology. The storage facility will be put into

operation this year, with a storage capacity of 30 MWh, equivalent to the daily power consumption of 1,500 German households. It is expected that during the commercial operation phase, the cost of electric energy provided by this technology will be much lower than 0.1 Euro per kWh. Similarly, government funding has also invested in the combination of renewable energy and hydrogen production technologies, which can help the full utilization of energy when renewable energy is more than the load.

ii. China constantly improves its energy policy framework to boost the wind power industry

The development of wind power is inseparable from policy support. It is a common practice worldwide. In the 1980s and 1990s, Europe and the United States began funding the development of wind turbines, adopted preferential prices for wind power, and provided tax returns. In 1986, China's first commercial wind turbine was connected to the electricity grid, and since then China has started technology import as well as its own development of wind industry. China implemented the Renewable Energy Law on January 1, 2006, which provided tremendous support to the large-scale development of renewable energy in China with priorities being legally granted to the development and utilization of renewable energies.

China's wind power installations exceeded 20 GW in 2009, and reached 44 GW in 2010, surpassing Denmark and Germany. In 2012, China overtook the United States to become the world's largest wind power market. Furthermore, wind energy development has also spanned from the centralized wind power development in the "Three North" regions to the decentralized wind power

development in the southeast and central regions. Offshore wind energy developed also took off.

The history of Siemens Gamesa in China can be traced back to 1988. The first wind turbine of the company in China "Bonus 55 KW" was installed in Dacheng Island, Zhejiang Province. Over the past 30 years, we have participated and witnessed the development of the wind power industry of China. China has also become an important wind turbine manufacturing and supply chain base of Siemens Gamesa in the world. In the era of smart wind power, driven by high-quality manufacturing and the "Internet +" strategy of China, Siemens Gamesa's big data application technology and experience accumulated across the globe could support the Chinese wind power industry to be digital and smart.

iii. China still has the huge potential to develop wind power

1. There is a huge potential for further development of the power market in China. Given the existing wind power technology, wind energy resources of China can achieve an installed capacity of more than 2000GW. Wind power can be an important part of the future energy and power structure. Decentralized development will become an important direction for the transformation of wind industry in the future. Compared with centralized wind power development, decentralized wind power matches well to the natural conditions and characteristics of the mid-eastern and southern regions, and can effectively utilize decentralized wind energy resources and improve wind energy utilization efficiency. In accordance with the statistical data of the National Meteorological Bureau, while the wind resource reserves of 6m/s are only 300 GW in the mid-eastern and southern regions, the reserves of 5m/s developable wind resources are

nearly 1000 GW. In Germany, the installed capacity of wind power of unit national territorial area in several German states is up to 300kW/km2, with an average of 136kW/km2. It is only 10kW/km2 in Hunan province and only 50kW/km2 in Jiangsu province, far less than the German level[iii]. The potential for wind power development in the mid-eastern and southern regions is huge.

2. Wind power development brings energy, environmental, economic and social benefits. According to the estimation by IRENA, the Chinese wind power industry employed 510,000 people in 2017, accounting for 44% of the global wind industry employment. With the accelerated development of offshore wind power which has a larger demand for labor, the localization of the wind power equipment industry chain and the increase of wind power equipment exports from China, the wind power industry of China will create more employment opportunities. Some research shows there will be 1 million people employed by the Chinese wind sector by 2020, with industry output value exceeding 300 billion yuan. In addition, the wind power industry of China can save 150 million tons SCE per year, reduce 380 million tons of carbon dioxide, 1.3 million tons of sulfur dioxide, and 1.1 million tons of nitrogen oxides, saving 500 million cubic meters of water annually. Although wind power has been criticized for some problems like resource stranding and state subsidies during its development, we should see the environmental and social effects and the potential opportunities for local industry transformation and upgrading brought about by wind power development.

3. China is expected to promote global cooperation in the field of wind power. China has not only maintained the world's largest installed capacity of wind power for many years, but also has exported wind turbines to more than 30

countries around the world. While China is promoting high-quality development of its manufacturing industry and implementing the Belt and Road Initiative, the Chinese wind power equipment manufacturers, engineering contractors and investment developers will be actively involved in the booming wind power development opportunities of the countries along the Belt and Road, and Chinese enterprises and global enterprises can jointly participate in overseas projects to achieve mutual benefit and win-win results. Compared with Chinese enterprises of about 10 to 20 years of overseas development experience, mature multinational or global companies have been operating in overseas markets for more than tens or even hundreds of years. Global companies' rich understanding of local countries and communities, mature overseas project execution experience, and risk management capabilities will help Chinese companies go out successfully.

II. Challenges encountered in the development of wind power in China

During the Twelfth Five-Year Plan period, China’s wind power has become an alternative energy instead of supplementary energy. Alongside the rapid development, it also encountered problems like grid connection and absorption difficulties, unorderly expansion and industry overcapacity, unstable manufacturing quality, and insufficient R&D, etc. Thanks to policy guidance and market-driven development, these problems have been basically resolved or being dealt with. In the Thirteenth Five-Year Plan period, the main problems and challenges are manifested in the following aspects. Only when these problems are effectively solved, can we not only accomplish the goals set in the Thirteenth

Five-Year Plan in figures, but promote the long-term and sustainable development of the Chinese wind power industry.

1. **The construction and operation of wind farms have more or less impact on the local environment.** Simply speaking, during the construction period, the booster station, the wind turbine foundation and the box transformer substation, the access road, the laying of current collection wires, and the temporary buildings of construction such as the construction site work shed and the warehouse, all of these projects have to occupy the surface and damage surface vegetation during construction. In the construction preparation stage for the wind turbine foundation and box transformer substation areas, the current collection circuit area and construction inspection road area, clearing of crop roots, peeling of planting topsoil, site leveling, etc., would cause the disturbance of original topography, removal of mulch (crop), and exposure of a large area of the surface. The soil erosion mainly results from the moderate water erosion caused by the slope formed by excavation and temporary pile up of topsoil during the construction period. The noise during the construction period mainly comes from construction machinery and transportation vehicles like cranes, excavators, bulldozers, loaders, smashing machines, vibrating needles and vibrators, abrasive cutoff saws, and air compressors. During the construction period, the wastewater and domestic sewage are from the construction water and the drainage of the construction workers' domestic water. Construction water is mainly used for concrete maintenance and dust reduction spraying at the site. The solid waste generated during the construction period mainly includes the domestic garbage of the construction workers and the earthwork generated during the construction process. During the operation period, wind turbines may bring about

noise, the operation of the boosting station may generate noise, and the rotation of the wind wheel and the noise generated may cause the low flight birds to fly and to be disturbed. Therefore, in the design stage of wind farms, it is necessary to take into full account how to minimize or eliminate these effects and reduce damage to the environment. Furthermore, the government should require development enterprises to comply with strict environmental requirements, and be aware of the impact of environmental requirements on the cost of the project.

2. The impact of continuous reduction in wind power feed-in tariff on the entire industry chain. The domestic wind power feed-in tariff has been formulated by the National Development and Reform Commission in accordance with the four types of wind zones, and is composed of local thermal power benchmark tariff plus a certain degree of subsidies. Wind power subsidies have played a very important role in the development of wind power in the past. However, the delay payment in the subsidy of electricity prices in some areas has also caused great problems for developers. With the development of wind power technology, de-subsidizing wind power projects are inevitable. The feed-in tariff of wind power has been on a downturn for the past few years, and in 2018, the National Energy Administration announced that wind power of China has officially entered the quotas auction stage, which has brought great influence to the wind power industry.

Under the premise that the construction cost of wind farms cannot be greatly reduced at this moment, price reduction of wind turbines has become the only way to accommodate to the auction scenario. Therefore, we have seen that the price per kilowatt of wind turbines has dropped sharply since 2017. Wind turbine

manufacturers can only achieve a reduction in the overall price of the unit turbine by imposing price reduction of all parties in the supply chain. However, the price recovery at the end of 2018 reflects the fact that the price decline in all parties has exceeded their tolerance capacity. The market price since the beginning of 2019 is still returning, and major manufacturers still bear large price pressures.

Under the guidance of the policy of achieving the same price of wind-thermal power after 2020, many grid parity demonstration projects have been carried out in China, with relatively good results. This shows that the price of wind turbines does have some space for decline, but it needs to be based on a sound and complete project preparation process. On the basis of sufficient preliminary inspection and design, detailed and complete project plans are formulated, no matter in the selection of the unit, the arrangement of the project, the optimization of various important components, and the precise management of building and construction, and the input-output ratio of the project is calculated accurately so as to get a reasonable unit price, and the corresponding feed-in tariff.

3. **The impact of the grid environment on the construction of wind power projects.** Wind energy resources are unstable and wind power is relatively volatile. Therefore, wind power has a greater impact on the power grid than traditional energy sources. European countries also met gird connection and safety issues in the early days of wind power development, however experience prove that such grid issues could be resolved thanks to technology improvements, and wind power can be smoothly connected to grid for stable operation by effective resource allocation and dispatch planning. In the early time of wind farm development in China, as there are not systematic standards of the wind

technology, then a relative big phenomenon of grid connection is without testing. Accidents in the later period, despite of remedial measures, caused considerable losses to many projects and related enterprises. After a large-scale wind power outage accident occurred in 2011, the grid company has formulated a more stringent wind power grid-connected policy, requiring strict testing in terms of power quality and low voltage ride-through before granting of a grid-connection license. In the past year, more stringent high voltage ride through technology has also been talked about in the industry. These requirements place more stringent requirements on the technology of wind turbines.

In the future, wind power will take an increasing share of energy mix. Long-distance and ultra-high-voltage power transmission will be massively put into use. Therefore, wind power development needs to accommodate grid adaptability and safety requirements including coordinated technical standards, transmission capacity, supporting power supply etc. In addition, when the grid safety and technology standards are defined, there should not be other arbitrary obstacles for on-grid. For example, the forced disconnection for wind power to grid in coal-heating winter season or rainy season for hydro power is a waste of energy and loss of energy efficiency.

4. Non-technical costs affect wind power development. The overall manufacturing and labor costs in China should be lower than the level of developed countries, but the price advantage of China's wind power is not prominent on the international market. Non-technical costs are the main reason. In the past, hot topics were focused on how to promote technological progress, making renewable energy such as wind power a more reliable and more efficient

form of energy, thereby reducing the cost of wind power development. With the advancement of technology and the accumulation of experience, the technical capabilities have been able to meet the demands for current large-scale development and utilization of renewable energy. Nowadays, how to improve institutional mechanisms to make it more adaptable to the current large-scale development and utilization of renewable energy will be an important driver for renewable energy development in China.

5. The development of offshore wind power. From the end of 2018 to the beginning of 2019, Guangdong, Jiangsu and other provinces have successively approved large-scale offshore wind power projects. This will help accelerate the offshore wind power development, however, it also caused some market concerns. Different from onshore wind power, offshore wind turbines are characterized by large scale and long power generation hours, and have higher technical requirements. Furthermore, offshore wind farms will be affected by harsh natural conditions such as typhoons, salt sprays and earthquakes. Therefore, offshore wind power needs relatively high investment costs and operating costs, and also faces some safety risks. From the development experience of Europe, the origin of offshore wind power, European wind turbine models generally undergo long-term model certification and prototype testing, as well as a typical delivery period of about 3 years. At present, related service system of offshore wind power supporting industry is still not perfect in China, and industrial chain construction, technical standards, engineering standards etc still need to be strengthened. The advantage lies in that the ready-made experience in Europe can be absorbed and the previous mistakes can be prevented. However, the impulse of

Chinese users to pursue cost reduction may pose certain potential risks to the development of offshore wind power.

III. Core policy recommendations

1. Coordinated development of wind power and environmental protection. Although wind power projects may have a certain impact on the local environment, some excellent projects at home and abroad also confirmed that under the premise of strict and thorough pre-design and construction processes, wind power projects can live in harmony with nature. The development of wind power projects and the protection of ecosystems could supplement each other. Environmental protection and forestry authorities should formulate environmental protection policies according to local conditions and realities, strengthen the beforehand and afterwards supervision, and avoid management through banning and "sweeping approach". Of course, wind power development enterprises should also firmly establish environmental protection and safety awareness, and adopt timely and effective ecological environmental protection and restoration measures. The report of the 19th National Congress of the Communist Party of China proposed to maintain a harmonious symbiosis between man and nature. It is necessary to establish and practice the concept that green water and green hills are the mountains of gold and silver, and adhere to the basic national policy of saving resources and protecting the environment. Therefore, relevant departments at all levels should more strictly consider the impact of the applied wind power project on the ecological environment of the location when reviewing the wind power project. A bidding offer, when selected, should consider the investment in

environmental protection and historical performance in order to truly reflect the green sustainable development concept.

2. The economic benefit of the wind farm should be assessed throughout the life cycle. The life cycle of a wind turbine includes the manufacturing, transportation and installation, operation and maintenance, abandoning, dismantling and recycling of a wind turbine. At the moment when foreign wind farm developers choose which wind turbine brand to use, they already started to consider the maintenance of the entire operating life of the wind turbine and generally sign a "2+10" or "2+20" wind power service agreement with wind turbine manufacturers. That is to say, after the first two years of the warranty period, the operation and maintenance service will continue to be provided by the wind turbine provider to ensure the stability of the operation of the wind turbine and the efficiency of power generation. At present, many wind power projects in China are mainly considering initial procurement, installation and construction costs. China should strengthen policy guidance in formulating relevant policies to advocate for lifecycle view.

3. The development of offshore wind power should proceed gradually and could learn from the mature experience in Europe. The installation surge that photovoltaic companies and onshore wind power have experienced as a result of incentive policies should be avoided, and "curtailment of wind and photoelectric power" causing waste of resources should also be avoided. European offshore wind power has significantly reduced its dependence on subsidies due to drastic reduction in costs brought about by technological advances and under the auction mechanism. The offshore projects currently approved in China rely on higher

tariff with government subsidies. When developing offshore wind power, China should minimize the gap with European standards in terms of technical and safety standards so that it can better introduce European mature experience into China. In addition, when introducing projects, local governments should stop the requirements for local investment or establishment of factory by a foreign turbine provider. In addition, local requirements for data storage and circulation have, to a certain extent, restricted the entry of foreign advanced technologies and applications into China. Compared with onshore wind power, the full lifecycle cost assessment of offshore projects is even more needed. The environmental impact of offshore wind projects, equipment maintenance and the cost of recycling decommissioned equipment should be the basis for decision-making in equipment and project development. Moreover, the government should strengthen guidance with related policies.

4. **Establish a reasonable reduction mechanism for electricity tariff.** When adjusting the feed-in tariff of wind power projects, the government establishes a reasonable mechanism for reducing the tariff, and adopts a gradual approach to avoid a dramatic slump in the industry. Enterprises also need to gradually get rid of subsidy dependence through continuous independent innovation. The government must formulate practical measures to reduce the non-technical cost of renewable energy power generation and improve the sustainability and predictability of policies.

5. **Increase the openness and inclusiveness of the market.** The wind power market of China is almost exclusively dominated by Chinese companies because of the price advantage of domestic wind turbine manufacturers. In recent years,

the overall market share of foreign brands in the Chinese wind turbine market is about 5%, which is a relatively rare industry phenomenon. Although China had canceled the requirement of “localization rate not less than 70%” as early as the end of 2009, a trend of price competition persisted in the rapid development of Chinese wind power market right after. The number of wind turbine manufacturers was sharply reduced from the maximum 60 to more than 20 presently, and many foreign companies withdrew from the Chinese market. Survival of the fittest and enterprise integration will help enhance the overall competitiveness of the industry. However, we hope that both Chinese and foreign companies can achieve sustainable and healthy development in business and finance in the Chinese wind power market. In the era of auction and grid parity, price is still an important factor, but as China enters a high-quality development stage and vows to open more market opportunities, the government should pay more attention to sustainable development, and take more account of the entire bidding proposal and life cycle value. In this regard, the experience of international enterprises also has important reference value. In addition, it is necessary to take solid action to eliminate local protection and create equal opportunities for Chinese and foreign-funded enterprises under a common standard for technology and quality configurations.

6. Cultivate green consumption concepts and values.
In 2016 and 2017, China issued documents to promote and guide the green consumption concept in the whole society. In July 2017, the National Green Power Certificate was implemented and the voluntary subscription transaction was officially launched. At present, the participation in Green Power Certificate trading is still dominated by new energy companies. In foreign countries, many

industry-leading companies increase the use of new energy in their own production and operations, reducing carbon emissions and environmental impact. For example, Siemens AG has promised to reach carbon neutral by 2030. China proposes that except for specialized non-fossil energy production enterprises, non-hydroelectric renewable energy generation capacity of all power generation enterprises should reach more than 9% of the total power generation; each power generation enterprise can complete the non-hydro renewable energy ratio target through certificate transactions. From the policy level, China can encourage the participation by large state-owned enterprises and institutions, as well as non-energy companies, in combination with voluntary and compulsory transactions. In addition, for ordinary consumers to participate in green power consumption, consumers can be appropriately subsidized in some areas in combination with regional development imbalances. Of course, building social consensus and promoting green consumption will be a gradual process.

IV. Conclusion

The further development of wind power involves technical and policy aspects. At the technical level, major wind power equipment manufacturers are constantly developing new technologies. The application of these technologies, especially big data-based technologies, will bring the cost of wind energy further down thanks to smart turbine design, manufacturing, operation and maintenance. This will shorten the lead time to grid parity. In parallel, R&D on renewable storage technologies will add to the availability and stability of wind and solar energy. Wind sector is no exception to big data, however, the analysis and application of dig data will require cross-regional and cross-border flow of data to some extent

in order to maximize the value of such data, which requires policy support as well. At the policy level, the development of offshore wind power and distributed wind power needs detailed technical and safety standards in place for implementation, and the absorption of wind power also needs policy guidance. Furthermore, the development of wind power also needs the consumer end, including enterprise users and ordinary consumers, to raise their awareness of the use of green energy and environmental protection. It is a very effective way to reduce the cost of wind power, but the government's responsibility is to act in their own ability to implement the concept of green development, for example, granting subsidies in early stage of industrial development, and raising the ratio of green energy in government energy procurement to set a good demonstration example. Greater development of renewable energy can be only achieved when green development is internalized into a common value for the whole society.

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[i] Internal Energy Agency, World Energy Outlook 2017.
[ii] International Renewable Energy Agency, Renewable power: Climate-safe energy competes on cost alone 2018
[iii] China Wind Energy Association: China Wind Power Industry Landscape 2017