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SUPER ENGINEERING

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Tianrun Xia County phase III 99.5 MW wind power engineering technology and green innovation

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Developer and owner: Beijing Tianrun New Energy Investment Co., Ltd.
Designer: China Energy Engineering Group Shanxi Electric Power Engineering Co., Ltd., Tongji Architectural Design (Group) Co., Ltd., Huadian Electric Power Research Institute Co., Ltd.
Construction contractors: China Energy Engineering Group Tianjin Electric Power Construction Co., Ltd.
Supervisor: Hunan Youyuan Engineering Supervision Consulting Technology Co., Ltd.

Located in Xia County, Yuncheng City, Shanxi Province, Tianrun Sijiao Town Wind Farm will have a total installed capacity of 250 MW as the Project planned. The 99.5 MW installed capacity of the Third Phase Project is developed by Xia County Tianrun Wind Power Co., Ltd. This project belongs to the fifth batch of wind power projects of Shanxi Province in the "Twelfth Five-Year Plan" Period approved by the National Development and Reform Commission (as shown in Fig. 1). The Project started on July 17, 2017, since its inverse feeding on July 22, 2018, it has been operating safely and steadily according to the power grid dispatching regulations.

Pursuant to the socio-economic development and power system development plan of the wind farm area, as well as the conditions for wind farm construction, and the requirements for development and utilization of wind energy resources, the primary task of the wind farm is to generate electricity. The project is mainly composed of three parts: wind turbine generator (WTG) system engineering, pit road engineering and electric power engineering. A total of 39 WTGs with 2500 kW power per unit and 1 WTG with 2000 kW power per unit have been installed and equipped with 40 Box-type 35 kV transformers.

To plan for the on-site integral hoisting and delivery sequence, the project maintains close ties with various equipment manufacturers, communicate the tower manufacturers in advance . Given that the roads on the site are mostly mountain roads with ups and downs and curves, the contract shall clearly state that high-performance special transport vehicles that meet the conditions for mountain transportation should be used in strict accordance with the requirements of the road survey report. Land requisition, occupation and compensation constitute the key points and difficulties in the project construction, and can directly affect the project schedule and costs. Before planning for land requisition, we must understand the ownership relationship and the difficulty of communicating with the householders, to avoid as much as possible the hard-to-solve land occupation-related problems. When planning the route, avoid as much as possible the occupation of villagers' arable lands, the optimal route should be selected, and the land compensation standard should be unified. Reinforce the management and coordination of the units participating in construction, and minimize hindrance and disturbance. Being familiar with the design drawings and new policies for local environmental protection inspection and acceptance, to ensure that they are consistent. Strengthen the management of construction site safety, quality, and progress, ensure the smooth development of the project; actively cooperate with the Company's Environmental Facility Department and the Safety & Quality Department to carry out relevant work in accordance with the company's requirements. While performing the project itself, strengthen the technical

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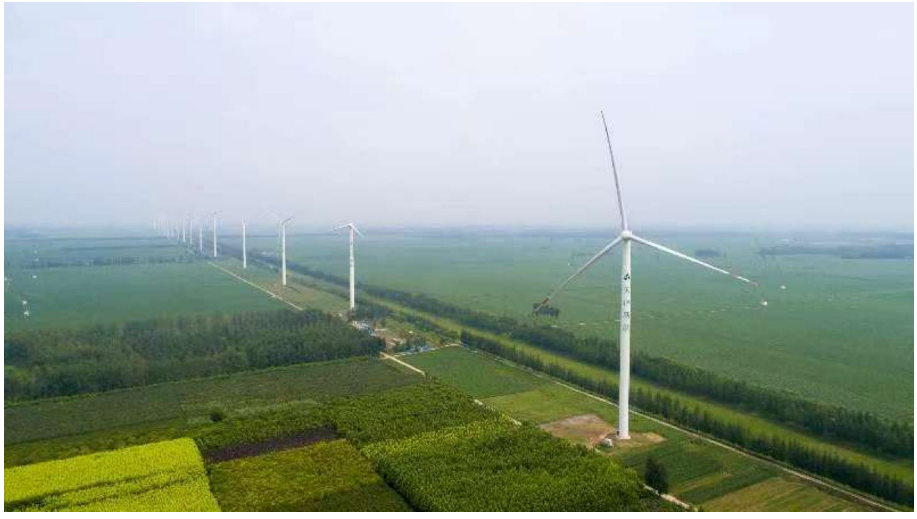

Fig. 1 Tianrun Sijiao Town wind farm project

communication with the production and operation units, to ensure that the Phase III punch list and defect elimination are completed as soon as possible. All these measures are taken for completion of the project work tasks.

The project department adheres to the policy of "safety first, prevention first, and comprehensive management." In alignment with a series of safety production documents issued by Beijing Tianrun Company, we formulated the second plan and implementation details of safe and civilized construction, the safety objectives were determined, the targets were decomposed, the safety supervision implementation procedures were clarified, and the admission safety education was performed.

Before the start of construction, the construction organization design was carefully reviewed. The key review ensured that the safety management organization is sound, the division of responsibilities is clear, the measures are perfect and reliable, and the safety regulations and management requirements were met.

During the construction process, all full-time personnel conducted inspection tours, special inspection, and key control points stand-by supervision, and gave play to their role for safety supervision. The Project Management Department (PMD) organizes the study of safety production documents every week, summarizes the safety construction situation of the previous week, focuses on the analysis of the dangerous points in construction of the next week, and organizes those in charge of the construction units to conduct on-site safety inspections and implement the next-step safety work. PMD organizes the person in charge of the construction unit and the safety officer on a monthly basis to conduct a large-scale inspection on safe and civilized construction, urges the rectifications of problems detected as per the "engineering contact list," and reviews the rectification results. PMD actively participated and cooperated in the multiple safety inspections of the grid companies and the quality supervision stations, and resolved the problems found in the inspections case by case.

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Considering that the transportation of towers, blades, generators, and other equipment constitutes a long-term crushing on the roads, the foundation of which becomes soft, coupled with the big slope of the turnings, to ensure the safety of on-site construction, PMD organized project management professionals, chief inspectors and construction team professionals to jointly investigate and confirm the actual situation on-site. After performing cost-effectiveness analysis, PMD timely adopted two kinds of road hardening measures to paved the roads with mud-gravel and cement stabilized macadam base, or concrete pouring, after which the safety transportation and traction of towers, blades and other heavy-duty equipment were guaranteed significantly, the number of tractors was reduced, thus the chance of safety accidents was decreased and the hoisting and emplacement process of the wind turbines was greatly accelerated.

Strictly control the starting point of process quality and the commencement of projects. After the establishment of the PMD, civil engineering and electrical specialists, etc. have prepared professional implementation rules as

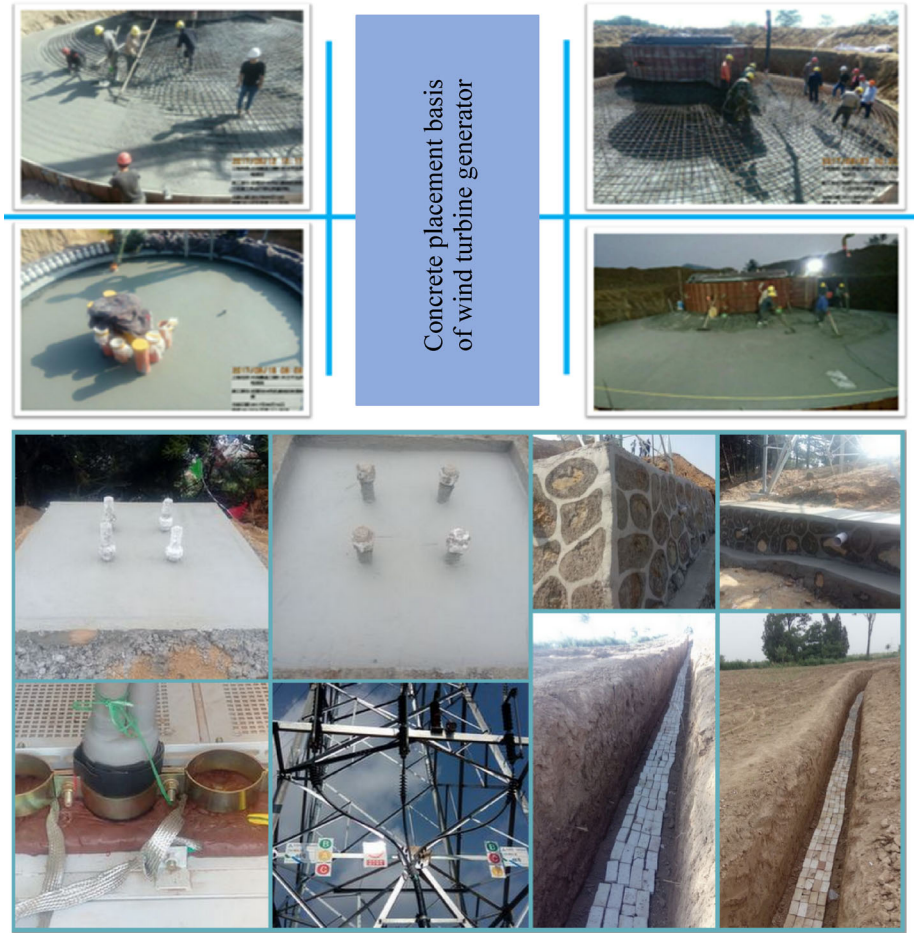

Fig. 2 The compiled directive diagram of relevant quality standards for project management

standard operation documents (as shown in Fig. 2). Through the implementation of standardization management, the management policy was formulated, the management objectives were determined and decomposed, the management procedures and responsibilities were clarified, the business and technical quality and moral and legal concepts of all employees were escalated, and the work in-place rate topped 100%.

The construction phase is a critical stage in the formation of project quality. Regular inspections are conducted to check if the management personnel of the construction unit, especially the QC in chief, is in place; if the quality management system is operating normally; and if the third-level quality inspection system is implemented, etc., and the following methods are adopted to control the quality of the project. Partition the units, divisions, and sub-projects to make the construction process and project reports well-grounded, with clear quality objectives and orderly quality control. Strengthen equipment inspection application and testing. The construction unit must be required to inspect and mark the construction materials, components and spare parts upon receipt, and perform witnessed sampling. After passing the inspection, the receipt shall be signed by the supervisor, and the equipment unpacking inspection system shall be carried out to conduct the pre-installation test. Untested materials, components and equipment or those disqualified upon inspection shall be forbidden for use in this project.

Tour inspections are adopted for stand-by supervision and acceptance of key processes, key parts, and concealed works. The hold points must be inspected and accepted before being transferred to construction and other approaches. Well-documented whole process supervision, inspection and control shall be applied to the workers, machines, materials, methods, links and environment of construction.

During the startup and commissioning of the single machine and the whole set, the PMD established the Start-up Inspection and Acceptance Committee, which consists of the command group, inspection and acceptance group, trial production group, troubleshooting and commissioning group, emergency response group and logistics group. The responsibilities related to the entire startup and commissioning have been divided and clarified for each group to lay an organizational foundation for smooth start of the work. During the grid-connection commissioning and test

run of the unit, PMD shall promptly contact the designer, manufacturer and other relevant units for organized handling of the problems reflected in the trial operation. Up to now, the units have been running stably, all indicators are excellent, the utilization rate is 100%, and the power curve meets the contract requirements.

In the phase of Green wind power of the Project, we will establish in advance a green standard system including equipment manufacturing, project construction, power generation and operation under the premise of "building wind power with green standards, and consciously fulfilling social responsibilities." Starting from the establishment of a green industrial chain system and the life cycle theory, we will clarify the technical requirements and evaluation standards for equipment manufacturing, project construction, green design in project operation and maintenance, green procurement, green construction and green production, to construct a green wind farm, mitigate, reduce and eliminate the impact on the ecological environment during the construction period of wind power project, and promote the sustainable development of wind power exploitation and construction.

The concept of "Green Hills and Clear Waters are Mountains of Gold & Silver (Green environment furnishes an endless wealth)" proposed by General Secretary Xi Jinping is an important idea of sustainable development. Building beautiful China and protecting the ecological environment have become the consensus of the people of China. Governments at all levels have responded to the call of the General Secretary and issued a series of planning and policies for ecological environment protection. Our wind power resources need to be built on the mountain, thus the requirements for environmental protection and ecology are very high. The Project actively and consciously implements risk control and construction in relation to environmental protection, ecology, soil and water conservation, to ensure green development of the Project, and that the environmental protection, soil and water conservation, and construction are controllable and under control.

Taking into account the engineering practice, we took the lead in constructing a green wind power evaluation standard system and criteria, covering the Project's five stages: R&D, design, procurement, construction, operation and maintenance; as well as the product and service processes in equipment manufacturing, engineering construction, production, operation and maintenance. The evaluation dimensions encompass economization (energy saving, water saving, land saving, material saving), environmental protection (environmental protection and water conservation projects, selection of environmentally friendly energy-saving materials and equipment, protection of biodiversity), low carbon (green supply chain, forest protection, selection of low-carbon equipment and materials), health (drinking water quality, electromagnetic radiation, noise, and indoor air quality).

The sites are selected on a scientific basis for efficient use of wind resources; and the design meets the requirements for land saving, material saving, water saving, and energy saving. We use environment friendly materials to achieve low carbon design, meeting the requirements of environmental protection. Our green procurement requires materials to be low carbon and environment friendly. Our major equipment suppliers shall meet the requirements of the green supply chain. Our green construction requires protection of biodiversity and surface water bodies in the area, the optimization of temporary land occupation, and appropriate disposal of solid wastes. In particular:

Energy saving: Energy conservation in the construction process and power generation operation and maintenance. From the design, procurement, construction, operation and maintenance stage, we select, purchase, install and use the following energy-saving measures and equipment to reduce the field power consumption rate: (1) Adopt energy-saving, high-efficiency and environment-friendly construction equipment in various on-site construction activities, say energy efficient motor. (2) In alignment with the natural conditions of the site, we reasonably design the shape, orientation, spacing and window-to-wall ratio of offices and temporary living facilities. (3) The temporary facilities adopt color steel thermal insulation composite wall and thermal insulation roofing, as well as doors and windows with good sealing and heat insulation, vouchsafed with product qualification certificates. (4) The indoor air conditioning temperature setting shall not be lower than 26°C in summer, and higher than 20°C in winter. Doors and windows shall be closed during air conditioning operation. (5) Energy-saving lamps should be used for lighting at construction sites, office areas and living areas. Use energy-saving indoor and outdoor lighting appliances that are equipped with reactive power compensation to reduce power consumption; high-intensity gas discharge lamps for outdoor lighting; thin-tube fluorescent lamps for offices; and compact fluorescent lamps for living areas. (6) The heat source of the bathroom hot water of the staff in the living area of the construction site relies mainly on solar energy, and supplemented by electricity. (7) A system of timely maintenance and warranty inspection is established for construction machinery and equipment such as tower cranes, construction elevators, and ground pumps. Arrange the processes reasonably to improve the utilization rate and full load ratio of various machines. (8) The electric meters are installed separately for electricity in construction and livelihood, whereby the construction area and living area shall be separately metered; the power supply shall be provided with eye-catching energy-saving identification; the construction site shall be established with lighting operation, maintenance and management system, and the electricity consumption nodes shall be established with statistical ledgers for analysis and comparison to improve the power saving rate.

Water saving: saving of water consumption during construction period, and saving of domestic water after the switch station is put into operation. (1) The water used in the construction area and living area should be metered separately, and eye-catching water conservation signs should be set at the water source. At the same time, the water consumption data of the construction site should be collected in time, and water conservation statistical ledger should be established for analytical comparison to improve the water saving rate. (2) Water-saving domestic water appliances shall be used for production and domestic use at the construction site, such as water-saving faucets for flushing tanks, toilets, and low-water consumption flushing toilets, etc. Environment-friendly mobile toilets can be used at the construction site. (3) Reuse of waste water. Use invariably reclaimed water for on-site vehicle wheel cleaning, sprinkling road cleaning to save water resources. (4) Inspect, repair, and replace all water supply valves on site on a regular basis to prevent water running, oozing, dripping, and leaking. (5) Groundwater resources protection measures shall be taken at the construction site, and it is forbidden to drill wells at the construction site to extract groundwater.

Land saving: Under the same installed capacity, reduce the permanent and temporary land occupation by booster stations, roads and fan decks by rational layout planning, selection of suitable machine models and optimization of construction arrangements.

Material saving: During the construction process, through reasonable design, we will reduce the weight of the wind turbine tower; reduce the waste of various materials on site, reduce the rework of non-conforming products; recycle the packaging materials, lifting appliance; rationally design the collecting power lines, the box and the built-in steel., cement, cables and other building materials. In-process material saving: (1) special programs such as scaffolding and formwork will be reviewed, the construction period will be reasonably arranged, the frequency of use of turnover materials will be accelerated, and the input and consumption of non-physical materials will be reduced. Adopt advanced processes and technology to reduce material loss and waste, and reasonably determine the premixed cement mortar admixture and mix ratio. (2) Try to use the original hardened road surface to ensure that the construction site is not dusty, and the bricks shall be subject to recycling use to reduce costs. (3) Establish a material usage ledger, strictly implement quota-based picking and central management by PMD. (4) Cement, sand, stone, aerated bricks and ceramsites for secondary structure and decoration are supplied strictly according to plan. For the amount of materials exceeding the quota, the amount of loss shall be clearly stated in the labor subcontract. (5) Establish a recycling team that is responsible for recycling scattered materials to ensure recovery. (6) Strengthen the control of the quantity of finishing materials in the later period, so that "long materials on the site are not used as short materials, and short materials shall take precedence over long materials in use." (7) For excessive losses or those not exceeding the loss rate, the labor subcontracting team shall be punished or rewarded according to the relevant incentive standards.

Environmental protection: The environmental protection and soil and water conservation project is carried out together with the overall construction (as shown in Fig. 3):

Fig. 3 Environmental management

(1) Temporary roads on the construction site are treated with concrete hardening, concrete bricks or gravels are laid as the floor of the material storage site, so that the loess is not in open-air. (2) Designate special personnel to clean the gravel road and material stacking with sprinklers every day, sprinkle water to reduce dust, to keep the surrounding air clean. (3) Cement and other easy-flying materials, fine-grained bulk materials should be stored tightly inside the warehouse. When transporting, it is necessary to prevent spillage and flying. When unloading, appropriate stacking measures should be taken to reduce pollution. (4) Cement warehouses, garbage stations, mortar mixing stations, etc. are closed with temporary brick walls, asbestos tiles, multi-layer boards and other materials. (5) The construction waste inside the building shall be bagged in a centralized manner, and transported to the ground via a separately designated, enclosed, and temporary garbage passage, or in a container for craning, or by the construction elevator. When the garbage is loaded and transported, a closed transport vehicle is used. (6) Set up the outbound vehicle flushing platform at the exit gate. Before the various dirty vehicles leave the site, the vehicle body must be flushed clean. (7) It is forbidden to burn construction waste and other substances that will produce toxic, harmful smoke and malodorous gases in the construction area. (8) In windy weather above Grade 4 Gale, earthwork backfilling, transshipment and other construction operations that may cause dust pollution shall not be carried out. (9) Decoration and finishing materials shall be those tested by the statutory testing unit as qualified, and the hazardous substances shall be assessed and inspected according to the requirements of relevant national standards and norms.

Prevent water and soil pollution: (1) Establish an effective sewage system at the construction site to ensure that the rainwater pipe network is used separately from the sewage pipe network. (2) Set up a septic tank in the living area, the sewage generated by the toilet shall be decomposed, and the septic tank will be treated at a fixed time and fixed location using a cleaning vehicle. (3) Set up food residue barrels in the living area for classification. (4) Set sedimentation tanks at the foreground of mixers and concrete delivery pumps, and the cleaning site of transportation vehicles, and regularly remove the sediments in the tank. Drainage ditch is planned uniformly for temporary roads on site and material stacking sites. (5) The water in the vehicle cleaning pool at the gate of the construction site shall be recycled, and the sedimentation tank shall be regularly cleaned. (6) Strengthen the management of on-site storage of oil and chemicals, for which special warehouses shall be set up, and the ground should be treated for anti-leakage. Measures should be taken during storage and use of oil materials, which should not be dumped at will to prevent oil running, oozing, dripping, and leaking.

Noise prevention: (1) The construction site shall follow the requirements of "Noise Limits for Construction Sites in People's Republic of China" (GB12523-1990) to develop noise reduction measures, test and record the construction site boundary to ensure that noise emission does not exceed national standards. (2) Taking into account the differed requirements for environmental noise standard (dB) at day and night, the construction process and operation time should be reasonably coordinated: the noise-intensive process should be carried out during the day, and avoided at night. (3) Hand-held power tools or cutting tools should be used in an enclosed area as much as possible. (4) All transport vehicles are prohibited from horning after entering the site, and loading and unloading cargo at night shall be handled with care to reduce noise.

Waste recycling: (1) Temporary dumping site of special wastes shall be designated at the construction site. The wastes shall be stored separately in a class-based manner. The wastes that may cause secondary pollution shall be stored separately, attached with safety precautions and eye-catching signs. (2) Waste transportation should ensure the absence of scattering or mix-ups of wastes, which shall be sent to a professional waste disposal unit or site for treatment and recycling. Recyclable wastes should be recycled. (3) A closed garbage station shall be set up at the construction site, and the wastes shall be sorted and cleared for recycling in time. (4) Special garbage collection stations shall be set up in the office, living areas and temporary residence, where special personnel shall be designated for daily cleaning.

Low carbon: Strictly check the production process of equipment and materials, the on-site construction, deforestation, and selection of equipment and materials. Determine the carbon footprint of each kilowatt hour electricity generation through carbon inventory; neutralize the carbon emissions from the whole process of wind farm construction through carbon emission reduction generated after power generation, including the carbon generated by production of power generation equipment, power transmission and transformation equipment, cables, building materials, production and office facilities, living facilities for the operation and maintenance staff of the wind farm, the carbon generated by human and the use of mechanical equipment during the construction process, and the carbon neutralization reduced by lumbering. Reduce carbon emissions by rationally designing, reducing the deforestation in the construction process, selecting and using low-carbon certified materials and equipment, and using clean energy in the operation and maintenance phase. Reduce carbon emissions by equipment and materials in the production process through raising requirements for the suppliers during the procurement process; reduce carbon emissions of in the power generation process by selecting energy-saving equipment.

Health: Reduce the indoor air quality pollution of the booster station by selecting environment friendly products; use safe and healthy drinking water by rationally selecting the water sources; ensure that the fan noise and electro-

magnetic radiation do not affect the health of the personnel in the booster station through reasonable design and layout. Elevators are installed in the wind turbines to reduce the labor intensity of the operation and maintenance personnel.

By the end of 2018, the Third Phase of Xiaxian Wind Farm Project has been operating normally for five months with remarkable composite benefits, achieving a harmonious and sustainable development between man and nature. It is our unchanging development philosophy to deliver an abundance of clean energy to the Yuncheng Prefecture, implement eco-friendly dispatch, provide blue sky and white clouds for human beings, and leave more resources for future generations.