

Questions to be responded to by the firm submitting the application

Why do you think this project should receive an award? How does it demonstrate:

- Innovation, quality and professional excellence;
- Transparency and integrity in the management and project implementation
- Sustainability and respect for the environment.

The Guohua Dongtai Demonstration Project of Wind-PV Hybrid Grid-connection, with installed capacity of 80MW in the wind farm and 20MW in the photovoltaic power station, making a total installed capacity of 100MW, is the first large-scale wind and photovoltaic power combined grid connection project now in commercial operation in China. The project was started for construction in 2011, completed in Dec. 2012, and connected to grid for power generation in Jan. 2013.

The project achieved good results on "power supply reliability, reactive power control, voltage quality and optimization of photovoltaic power generation capacity", with 2 invention patents awarded and 2 academic papers published, and has important demonstration and reference significance for the large-scale application of new energy in the future.

1. A challenging project with leading innovation results

Wind power and photovoltaic power generation are currently two important forms of renewable energy. In China, large-scale bases have been used more frequently as a development pattern of wind power and solar energy, and this pattern has the features of concentrated development, long distance and high voltage transmission. With unexpectable changes of wind speed and solar radiation, wind and solar energy power generation has the features of randomness and fluctuation. Therefore, concentrated grid connection of wind and photovoltaic power in large scale inevitably results in many challenges to the operation, dispatching and control of power system and energy quality. At present, there are three main technical bottlenecks affecting the large-scale grid connection of new energy:

(1) Power supply reliability. The output power of wind farm or photovoltaic power station cannot be maintained stable constantly, compared with conventional generator sets, the power supply reliability is low, producing poor effect in peak regulation in the power system.

(2) Low controllability. The intermittent operation of wind and photovoltaic power and the space difference of power generation units (wind turbines and photovoltaic modules) have greatly increased the difficulty of coordinated control between the grid and the wind and photovoltaic power sources. Among them, reactive power control is a prominent problem.

(3) Voltage quality. The output of wind and photovoltaic power is changeable and has transient impact, which can result in grid voltage fluctuation, affecting the grid voltage quality.

By relying upon scientific and technological progress and self-reliance innovation, on the basis of full study of the wind and photovoltaic power output characteristics, the creative design idea of generating power with wind and photovoltaic power combined together was proposed by breaking through the traditional design concept for Guohua Dongtai Wind-PV Combined Grid Connection Demonstration

Separate grid connection of just wind farm or photovoltaic power station, the wind-PV combined system can realize complementation and balance between wind power and photovoltaic power by smart utilization of the features of them. The innovation result of this project is mainly embodied on the following 4 aspects.

(1) Increasing power supply reliability

Wind and photovoltaic power generation has the inherent features of randomness and fluctuation. Separate traditional connection of wind and photovoltaic power generation to the grid will be difficult to realize sustained and reliable power supply. According to the existing research results and actual operation experience, the credible capacity of wind power and photovoltaic power (the credible capacity refers to the conventional generator capacity that can be substituted by new energy power generation equipment while reliability is assured) is normally about 30% of its installed capacity. As for this project, the credible capacity has been increased to about 40% of the total installed capacity, by making use of the complementarity between wind power and solar energy and connecting to the grid together, thus increasing the power supply reliability of wind and photovoltaic power. Based on this project, a method to evaluate the reliability of wind-PV grid-connection system has been developed and an invention patent was awarded.

(2) Advanced reactive power control technology

The traditional wind turbines and photovoltaic grid-connection inverters are controlled by unit power factor, difficult to meet the grid demand. In Guohua Dongtai Demonstration Project of Wind-PV Hybrid Grid-Connection, the reactive power regulation capacity of the wind power system and photovoltaic system has been brought into full play, the wind power output and photovoltaic power output prediction technology was introduced, to estimate the reactive power regulation ability of the wind and photovoltaic power generation systems in real-time, so that reactive power output can be adjusted in real-time according to the grid dispatching command, to meet the reactive power demand of the grid.

(3) Improving voltage quality

Wind farms and photovoltaic power stations are intermittent power sources, their connection to the grid can cause grid voltage fluctuation, therefore, independent grid connection of wind power or photovoltaic power with the traditional technology cannot ensure the rate of qualified voltage. When the wind and photovoltaic power are combined together to connect into grid, the random fluctuation of its output will be less than that of separate wind power output, and the probability of grid voltage random fluctuation will also be reduced. In addition, the project adopts advanced reactive power control technology, allowing reactive power output regulation according to grid dispatching, so that the qualified voltage rate can be over 99.5%.

(4) Breakthrough in grid connection capacity optimization control for photovoltaic system

Mature grid connection capacity optimization control methods for photovoltaic system have been obtained with the grid short-circuit current, voltage loss, voltage fluctuation and harmonics as the restricting conditions, and by realizing maximization of photovoltaic absorption capacity at grid connection point as

awarded. This patent was awarded with a third prize of the CEEC science and technology award.

The research results obtained in the Guohua Dongtai Demonstration Project of Wind-PV Hybrid Grid-connection are presented in Table 2-1, and the technological comparison with similar projects at home and overseas in Table 2-2.

Table 2-1 Research results obtained

	Description	Patent No./periodical
Patent	Grid-connected capacity optimization control method of photovoltaic power station based on four-element restriction method	ZL 2010 1 0121426.4
	Reliability evaluation method for wind and photovoltaic hybrid power generation system based on Copula theory	ZL 2012 1 0257428.8
Essay	Reactive power control strategy of grid-connection for the wind and photovoltaic hybrid system	Proceedings of the CSU-EPISA(Chinese)
	Probability evaluation of voltage random fluctuation caused by wind and photovoltaic hybrid grid-connection system	Proceedings of the CSU-EPISA (Chinese)

Table 2-2 Technological comparison with similar projects at home and overseas

Comparison item	Similar projects at home and overseas	The Guohua Dongtai Demonstration Project of Wind-PV Hybrid Grid-connection	Comparison and analysis
Energy combination pattern	Independent wind power and photovoltaic power generation	Wind and photovoltaic combined together for grid connection	Leading international level
Power supply reliability	Credible capacity is about 30% of installed capacity	Credible capacity is about 40% of installed capacity	Leading international level
Reactive power control technology	Unit power factor, difficult to meet the reactive power demand of the grid	Regulating reactive power output according to grid dispatching command, to meet the grid demand	Leading international level
Qualified voltage rate	Depending on grid structure and local wind speed and solar radiation characteristics	99.5%	Leading international level

2. Outstanding technology and excellent quality

(1) Saving land resources and improving operation management standard

In this project, the photovoltaic modules are installed on the shoal in the wind power farm, saving effective land resource of about 46.6 hectares; also, the wind power and photovoltaic power share 1 outgoing line, thus saving the land for line corridor compared with separate wind and photovoltaic grid connection. In the operation management of the wind farm and photovoltaic power station, the infrastructure and staffing are

...ent of this project becomes more accurate and effective. At the main control building of the project, the wind power and photovoltaic systems can be tested and controlled simultaneously, thus realizing the unified management of wind and photovoltaic power, greatly improving the work efficiency.

(2) Increasing the capacity factor of power equipment

The output from wind farm and photovoltaic power station has peak shift effect, and the project has made full use of this feature to extend the continual utilizing time of the main transformer and the transmission line, thus prominently increasing the capacity factor of the main transformer and outgoing line. The actual operation shows that the capacity factor of the grid connection power equipment for intermittent energy such as wind and photovoltaic power is 20%~25%, and this factor can be increased to about 35% in this project, which indirectly increases the investment efficiency on power equipment.

(3) Saving investment on power equipment

The wind and photovoltaic power bundled transmission can save the investment for 1 step-up main transformer and 1 outgoing line; advanced reactive power control technology is adopted, saving the investment on reactive power compensation device.

(4) Good safety and durability

The Guohua Dongtai Demonstration Project of Wind-PV Hybrid Grid-connection has been tested in operation for 2 years and 5 months, effectively withstanding the comprehensive tests of unexpected weather, variable wind and solar conditions and alternation of extreme cold and hot weather at the short-circuit fault in the grid, the project successfully responded to low voltage ride through, without any design or construction quality problem, and all monitoring data have remained stable and normal.

3. The project is of transparency and integrity

(1) For the project, bidding was invited on the basis of innovation and quality, and the form of bidding was open, transparent and competitive.

(2) The project was not involved in any commercial secrets, and the project consultancy and design followed the principle of openness, transparency and integrity.

(3) Integrity risk prevention of control system and its implementation plan were formulated in conjunction with the actual conditions of the project. Aiming at various risks that might induce corruption, risk points were identified through analysis and evaluation, and a comprehensive system was established for prevention beforehand, monitoring during works and handling after completion.

(4) In 2013, the project passed audit by relevant department, the conclusion is that the project capital was used in a rational and formalized way, and no engineer corruption problem occurred.

ronment.

- (1) The project can continually supply clean electric energy, generating high quality green electric power of about 200 million kWh every year, which means reducing coal equiv. of 63,000t in fissile fuel power generation annually; it can substantially reduce the emission of harmful gas, cutting carbon dioxide emission of 145,000t a year, equivalent to the carbon dioxide produced from combusting 6.34 million L of gasoline, or the carbon dioxide absorbed by 3.83 million 10-year-old trees every year.
- (2) In view of the fact that the project is located near the national red-crowned crane natural reserve area, a rational design was made to avoid the natural reserve area in the selection of outgoing line routing so as to effectively protect the inhabiting environment and migrating conditions of red-crowned cranes.
- (3) The project is located in the coastal area of Jiangsu, where the coastal shoal vegetation is fragile. In the microscopic siting of wind power units and photovoltaic modules, the coastal shoal vegetation distribution in Jiangsu was fully investigated, effectively avoiding damage to the vegetation.
- (4) The Wind-PV hybrid grid-connection system can save investment of about 30 million yuan on power equipment, with considerable economic gains; also, the construction of this project has promoted the development of the new energy power generation industrial chain in the coastal area of Jiangsu, provided more jobs and increased the GDP growth in the local area.

What services did the member firm provide to the project? Please describe briefly:

Jiangsu Electric Power Design Institute Co., Ltd. provided the whole consultancy and design for the project.

In the project approval phase, we provided the owner with consulting on aspects such as the project siting, technical line and investment and so on. For example, in project siting, we suggested the owner that attention should be paid on the routing of power outgoing line, investment and power transmission reliability.

In the project feasibility study phase, as there was no precedent application of wind and photovoltaic combined grid connection, we focused our research on the possible instability of wind and photovoltaic power generation and electric energy quality problems such as harmonic, voltage fluctuation and flickering resulted from power equipment, to remove the worries of the owner and electric power company. The authoritative computer software in the industry was used for simulation calculation of power flow, short-circuit and transient stability, and the recommended option was provided after comprehensive economic and technological comparison.

In the project preparation and implementation phase, we took initiative to discuss with the owner, to further optimize the models of power generation equipment and the overall design according to the latest development of wind power generators and photovoltaic assemblies. In the meantime, we also assisted the owner in rationally arranging the project implementation schedule, conducting bid invitation and equipment procurement and erection.