Zero-Carbon Factory Project

CECEP Solar Energy Technology （Zhenjiang） Co.,Ltd

PROJECT OVERVIEW

China Energy Conservation Solar Energy Technology (Zhenjiang) Co., Ltd., relying on its industrial advantages in the photovoltaic manufacturing field, takes "photovoltaic energy + digital intelligent manufacturing + hardware energy conservation" as the core path, and officially launched the construction of the "Zero-Carbon Factory" in Zhenjiang City, Jiangsu Province on January 12, 2022. Subsequently, it carried out a comprehensive zero-carbon upgrading with its smart manufacturing plant for high-efficiency solar cell modules (with an annual output of 1.5GW) as the main entity.By integrating energy-saving design of factory buildings, construction of full-roof solar photovoltaic systems, and establishment of an industrial Internet-based intelligent manufacturing platform, the company has built a system covering data collection, storage, processing and analysis for the entire process of energy "production, transmission, distribution, and consumption". This forms a set of implementable solutions for Zero-Carbon Factory construction and energy-carbon management, which not only realizes the zero comprehensive carbon emission of the factory itself, but also deeply integrates building energy conservation, green energy supply and digital intelligent manufacturing. It provides a "technically feasible, economically beneficial and replicable" low-carbon transformation model for the photovoltaic manufacturing industry and even the entire industrial sector.

COMPANY/ORGANIZATION PROFILE

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China Energy Conservation Solar Energy Technology (Zhenjiang) Co., Ltd. is a third-tier subsidiary of China National Energy Conservation and Environmental Protection Group Co., Ltd., which is directly under the State-owned Assets Supervision and Administration Commission of the State Council (SASAC). Its main businesses include the R&D, manufacturing and sales of crystalline silicon solar cells and modules, as well as the development and sales of hardware and software for artificial intelligence applications.

As a high-tech enterprise, it has obtained more than 10 innovation platforms such as national-level CNAS (China National Accreditation Service for Conformity Assessment) and TUV witness laboratories, and postdoctoral research workstations. It has 313 authorized patents, and its PVB double-glass module technology has won the "Third Prize of Science and Technology of Jiangsu Province". For ten consecutive years, it has ranked among the top 20 in global module shipments, and has obtained titles such as "Top 20 Chinese Photovoltaic Module Enterprises", as well as certifications including national-level "Green Factory" and carbon footprint certification.

PROJECT OUTCOME

1.On the energy replacement front, a "full-roof + curtain wall" photovoltaic energy supply network has been built, maximizing the use of factory space to implement distributed power generation and centralized grid connection. The total power generation is expected to reach 182.0328 million kW·h over 25 years. Compared with thermal power generating the same amount of electricity, it saves 2,400 tons of standard coal annually (calculated based on a standard coal consumption of 315g/kW·h), reduces emissions of sulfur dioxide by 3.6 tons and nitrogen oxides by 3.3 tons, and realizes the dual value of "energy self-sufficiency + carbon emission reduction".

2.On the digital empowerment front, a park-level online energy monitoring platform with core functions including real-time monitoring, comprehensive analysis and abnormal early warning has been developed, and 2 software copyrights have been obtained. It saves over 600,000 yuan in energy costs annually, reduces energy consumption intensity by 15%, cuts carbon emissions by approximately 12,000 tons per year and supports carbon footprint accounting. Through the platform's functions, operation and maintenance costs have been reduced by 30%, providing a replicable new energy management model for similar parks.

3.On the hardware energy conservation front, the foundation for carbon reduction has been consolidated through multi-dimensional measures: the improvement of the silicon wafer cutting process saves 1.018 million kWh of electricity annually, corresponding to a CO_2 emission reduction of 580 tons; the replaced high-efficiency epoxy resin vacuum-cast dry-type transformers save 40-50% more energy than traditional oil-immersed transformers; after reactive power compensation, the power factor of the power system reaches over 0.9; the optimization of building layout reduces ineffective energy consumption in transportation and line transmission, and the matching of circulating water systems improves the water reuse rate, achieving synergy between energy conservation and environmental protection.

PROJECT HIGHLIGHTS

1.Excellence Award for Typical Cases of Carbon Neutrality Technological Innovation under the "Belt and Road" Initiative

2.Jiangsu Province's "First Batch of Provincial-Level Carbon Peaking and Carbon Neutrality Pilot List"

3.National-Level "Green Factory", "Jiangsu Provincial Leading Enterprise in Green Development"

4.2022 Typical Case of Dual-Carbon Scientific and Technological Innovation

5.Carbon Neutrality Commitment Demonstration Unit, Green Design Demonstration Enterprise

PROJECT IMPLEMENTATION

I. Hardware Energy Conservation Measures: Addressing High Energy Consumption and Low Efficiency, Achieving Full-Link Energy Control with Internal and External Support

To tackle issues such as the enterprise's large and scattered factory layout (leading to high transportation energy consumption), high electricity consumption in the silicon wafer cutting process, and the dominant use of direct water supply (with a reuse rate of less than 60%), the project advanced transformation with the goal of "full-link energy control". During the process, it fully relied on the special construction funds of China National Energy Conservation and Environmental Protection Group and the support of cross-departmental technical teams:

In terms of building layout optimization, it broke through the traditional design limitation of "functionality first" and overcame the problem of high transportation energy consumption caused by scattered layout. Under the premise of meeting safety distances, buildings and facilities were arranged closely; meanwhile, power facilities such as substations and air compressor stations were moved to load centers to reduce energy loss in power supply, distribution and pipeline transmission. After implementation, transportation and transmission energy consumption has been reduced by more than 15%.

In the process transformation link, focusing on the pain point of high energy consumption in silicon wafer cutting, the traditional process was abandoned and the "thermal stress + high-precision micro-mist cooling" technology was adopted. To avoid the impact of transformation on production capacity, a "parallel operation of old and new production lines" mode was adopted for a smooth transition. At the same time, the layout of workshop equipment was optimized, and priority was given to the selection of dry-type transformers (saving 40-50% more energy than traditional oil-immersed transformers) and high-power variable-frequency drive equipment. Finally, the silicon wafer cutting link achieved an annual electricity saving of 1.018 million kWh, corresponding to a CO_2 emission reduction of 580 tons.

In the implementation of special electricity-saving measures, to solve the problem of extensive power management, qualified institutions were entrusted to conduct power balance tests and formulate plans every 2-4 years. High-voltage power distribution mode was adopted, air compressor stations were built centrally (equipped with high-efficiency and low-noise compressors), and high-low voltage hybrid compensation devices were installed. As a result, the power factor was increased from less than 0.8 to more than 0.9, significantly reducing power waste.

In the construction of the water-saving system, to solve the inefficiency of traditional direct water supply, the water use mode was upgraded to a circulating/series mode. A circulating water device was built to recycle equipment cooling water, and clean wastewater from the pure water system for process cleaning was treated separately. Meanwhile, metering devices were installed at the production water inlet and workshop wastewater discharge outlet, and facility maintenance was strengthened to prevent water leakage, greatly improving the water reuse rate.

II. Full-Roof + Curtain Wall Photovoltaic System: Optimizing Energy Structure, Overcoming Space and Safety Coordination Challenges

The original factory mainly relied on externally purchased electricity, resulting in high carbon emissions and persistently high energy costs. With the principle of "maximizing space utilization", the project built a photovoltaic energy supply network. During the process, it overcame the coordination challenge between factory roof load-bearing capacity and production safety—through professional structural mechanics calculations and phased construction by area, it ensured no impact on the original functions of the factory. At the same time, it obtained guidance from industry experts on equipment selection and advanced implementation:

First, a survey of the factory roof and facade wall space was completed, and a total installed capacity plan of 7.85345MWp was determined. Subsequently, 17,541 pieces of 450Wp monocrystalline silicon single-sided modules were selected, matched with 19 units of 320kW string inverters, 1 unit of 50kW string inverter and 2 units of 33kW string inverters, and a distributed power generation and centralized grid connection mode was adopted. Finally, the total power generation is expected to reach 182.0328 million kW·h over 25 years, with an average annual power generation of 7.2813 million kW·h. Compared with the pre-implementation mode of externally purchasing thermal power, it saves 2,400 tons of standard coal annually, reduces emissions of sulfur dioxide by 3.6 tons and nitrogen oxides by 3.3 tons, and realizes the dual benefits of "energy self-sufficiency + carbon emission reduction".

III. Park-Level Online Energy Monitoring Platform: Upgrading Management Mode, Solving Data Lag and Compatibility Issues

The original working mode relied on manual meter reading, resulting in low accuracy of energy data, long response time to energy consumption abnormalities (about 12-24 hours), and high equipment operation and maintenance costs. The development of the park-level online energy monitoring platform project advanced in four phases. During the process, a cross-departmental team covering photovoltaic, digital and process fields was established to solve the problem of incompatible communication protocols of multiple devices (by developing a universal data interface) and obtained external guidance on intellectual property application:

Phase 1 (Project Initiation): To address the problem of data collection blind spots, a comprehensive survey of the main power transformation system and water metering nodes was completed, a separated front-end and back-end + microservice architecture was planned, and implementation rules were formulated after passing expert review.

Phase 2 (Design and Development): Centering on the needs of "real-timeliness and precision", functions such as real-time monitoring and abnormal early warning were refined, requirements for minute-level data collection were clarified, and the User Requirements Specification was compiled.

Phase 3 (Implementation): Platform modules covering data collection, analysis and carbon emission accounting were developed. More than 10 main power meters and water-use equipment were deployed, debugged and connected. Multiple rounds of tests were conducted to ensure the data accuracy was improved to ≥99%.

Phase 4 (Acceptance): During the trial operation, functions were optimized based on feedback. After passing the final acceptance, 2 software copyrights were applied for. Finally, the response time to energy consumption abnormalities was reduced from 24 hours to 2 hours, equipment operation and maintenance costs were cut by 30%, annual energy cost savings exceeded 600,000 yuan, and energy consumption intensity decreased by 15%. At the same time, it supports accurate carbon footprint accounting for the enterprise, with a total annual carbon reduction of 12,000 tons.

PROJECT IMPACT & SUSTAINABILITY

The project deeply responds to the national "dual-carbon" strategy and provides a dual-dimensional reference in terms of technical pathways and management models for the construction of zero-carbon factories in the photovoltaic manufacturing sector. By virtue of photovoltaic energy replacement and full-link energy-saving measures, it effectively avoids the risk of power rationing caused by local power supply overload. Moreover, digital energy-carbon management helps the enterprise optimize its production structure, improve resource utilization efficiency, promote the development of circular economy, and successfully establish a benchmark for green and high-quality industrial development.

The project boasts extremely strong promotability: the "building energy conservation + photovoltaic roof + industrial Internet" solution is highly operable and can be integrated into the design during the enterprise's feasibility study stage. The online energy monitoring platform can be directly adapted to multiple scenarios such as industrial parks and industrial zones, supporting the access of multi-protocol devices like electricity meters and water meters of different brands. It is compatible with the existing facilities of most parks, requiring no large-scale reconstruction, which greatly lowers the threshold and cost of transformation. In addition, standardized outcomes including the User Requirements Specification and software copyrights provide ready-made technical templates, making the promotion highly implementable.

In terms of sustainability, the project has established a sound energy management system. Through daily management and control, it continuously reduces energy and resource consumption to ensure the long-term effectiveness of zero-carbon operations. At the same time, relying on the online cloud platform, it has built an ecosystem featuring "data empowerment + smart operation and maintenance + real-time monitoring", extends smart energy services, provides support for upstream and downstream enterprises, and promotes the synergistic development of green low-carbon and digitalization across multiple industries, thus possessing long-term sustainable economic and social value.

Expert Comments

Based on its photovoltaic manufacturing business, CECEP Solar Energy Technology (Zhenjiang) Co., Ltd. is systematically advancing the deep integration of building energy efficiency, clean energy supply, and digital and intelligent manufacturing to develop a "zero-carbon factory" with self-sufficient energy capacity. Centered on a "rooftop + curtain wall" photovoltaic power supply network, the project integrates an intelligent energy-carbon management platform with multi-dimensional energy-saving retrofits to achieve carbon reduction and energy efficiency improvement throughout the entire production process. Through coordinated explorations in energy structure, management systems, and digital transition, the company demonstrates the sense of responsibility of a central state-owned enterprise in advancing the development of green industrial regime, and also provides a practical model for the manufacturing industry to march toward high-quality and low-carbon development.