Exploring the Application of Energy-Saving and Environmental Protection Technologies in Residential Building Construction

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Abstract: Under the impact of the global energy crisis and the “dual-carbon” goal, all major industries have begun to pay attention to save energy and strengthen environment protection. In general, when constructing a residential building, it will produce a lot of waste during construction, which will pollute the surrounding environment. Therefore, for construction companies, adopting energy-saving and environmental protection technologies has become an important way to promote the sustainable development of the industry. The article details the importance of these technologies and discusses how they are specifically used in residential building construction with Solar energy technology, water-saving technology, wall heat preservation & energy-saving technology door and window optimization. The goal is to promote the reconstruction of the emission reduction route for low carbon development in the construction industry and provide key support for promoting the realization of China's green building magical targets.

1. Introduction

With the rapid development of urbanization in China, the residential building industry has ushered into a period of large-scale construction. Currently, energy consumption and pollution during the construction of residential building projects have serious problems that affect the ecological environment and residents quality of life. Previously, the national strategic goals of "carbon peak and carbon neutrality" have led to the issuance of policy documents such as the "Green Building Evaluation Standard" and "Civil Building Energy Efficiency Regulations," which explicitly required compliance to include residential building construction into energy-saving and environmental protection management systems. In this context, promoting energy conservation and environmental protection technologies in the construction of residential buildings is a practical requirement to relieve the energy crisis and enhance the ecological environment, but also an objective choice to guide the building industry from a traditional high-energy-consumption model to a low-carbon green model.

2. The Necessity of Applying Energy-Saving and Environmental Protection Technologies in Residential Building Construction

2.1 Helps Improve the Utilization Rate of Resources and Energy

Construction companies also have to deal with the traditional methods of construction used in residential building projects which are often very resource and energy intensive and therefore lead to large amounts of wasted energy. Without change, this is sure to worsen the global energy crisis. Scenario of high energy consumption and pollution has appeared at the same time, which generates energy-saving and environmental protection technology that provides a new way to improve energy utilization efficiency. New energy-saving building materials with excellent thermal insulation performance must be used in residential construction, which can effectively reduce the use of energy for heating or refrigeration. The utilization of energy efficient constructions equipment during construction can decrease the amount of energy used in operation and enhance the efficiency of energy consumption [1]. Additionally, through the optimization of construction processes and

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reasonable construction scheduling, preventing circular operations or idleness of resources, which enables full utilization of material, human resources and so on. The adoption of a series of energy-saving and environmental protection technology can effectively reduce the construction costs, as well as give strong assurance ensuring the sustainability of resources, which is in line with the long-term need for social development.

2.2 Helps Reduce Environmental Impact

During the construction of residential buildings, the dust produced pollutes the air, wastewater discharge pollutes water sources, and construction waste occupies land. Because the construction process can cause a wide range of adverse effects on the environment around its operations, it is crucial for construction enterprises to introduce energy-saving and environmental protection technologies to better avoid or reduce these problems. Dewatering waste treatment involves setting up dust control measures during construction, which is specific to companies and can be achieved by installing water sprinkling systems at the construction site for spraying; adopting enclosed construction methods to prevent dust from spreading; setting up wastewater treatment systems inside the company to dispose of or recycle construction wastewater to meet discharge standards, avoiding contamination of water sources; recycling or treating construction waste, reducing landfill volumes, and occupying less land resources. These measures can minimize the ecological environment damage caused by construction activities, as well as achieve a harmonious coexistence between construction and the environment while promoting the implementation of green construction concept.

2.3 Helps Reconstruct the Low-Carbon Development Path for the Construction Industry

Currently, the world is calling for low-carbon development. The construction industry as a large consumer of energy and carbon emissions, should continue to make efforts to transform into energy-saving and environmental protection. By making the use of new energy-saving and environmental protection technologies in the construction of residential buildings, a new road can be provided for the low-carbon development of construction. On the one hand, reflecting energy-saving concepts at the design stage, planning reasonable building layouts and orientations, and making full use of natural light and ventilation can greatly reduce dependence on artificial energy. Alternatively, promoting the use of green construction technologies and the use of renewable energy sources (solar and geothermal energy) promotes the industry's transition from a traditional "high-energy-consumption, high-emission" model to a low-carbon, environmentally friendly one. This leads the industry to reflect on its development method and seek a low-carbon development path that meets sustainable development requirements [2].

3. Specific Applications of Energy-Saving and Environmental Protection Technologies in Residential Building Construction

3.1 Application of Solar Energy Technology

Solar energy technology is an energy-saving and environmental protection technology with great clean and renewable ability. This can relieve the consumption of fossil fuels in residential building, and further realize its function advantages, such as temporary power supply and supplementary heating. The use of solar photovoltaic (PV) systems may suffice for temporary power supply, as they can run temporary lighting and small construction equipment. In certain implementation, construction staff must fully consider the actual size of the construction site and electricity needs at deployment level layout, according to scientific and reasonable configuration solar PV panels, storage batteries, inverter and such key equipment. Solar PV (PhotoVoltaic) panels convert sunlight into electricity, and storage batteries store excess power to stabilize construction electricity in no-light conditions, such as cloudy and rainy days, avoiding the suspension of construction due to weather changes [3].

In auxiliary heating applications, solar thermal collection systems can directly provide hot water

for construction and meet the daily needs of construction workers. In northern areas where solar heating is particularly useful during the winter months for construction projects, construction companies can supplement solar air collectors with a variety of heating systems to heat temporary buildings for construction workers, greatly reducing their fuel oil and gas consumption as well as lowering costs and environmental impact. For instance, with concrete curing, conventional methods of curing adopted by construction companies in winter involves extensive use of electric heating hardware to keep the temperature of water used for curtailment up which in turn leads to high energy consumption [4]. Solar heating systems can accurately control the temperature of curing water between 15–20°C, enabling electric heating equipment to save energy. Due to suitable temperatures, concrete strength development speed is significantly improved, allowing for a shortening (3–5 days) in the curing period, which effectively revamps construction efficiency and guarantees project quality.

3.2 Application of Water-Saving Technology

Water usage while constructing residential buildings is at a whopping rate. This article highlights the need for construction companies to use water-saving technologies rationally in order to conserve this natural resource. The application of this technology is mainly focused on three aspects: recycling construction site wastewater, rainwater collection and utilization, and configuration equipment for saving water. Construction companies should fully exploit these technologies to enhance the efficiency of using water in construction, alleviate water shortages that may occur during construction against better consumption costs in terms of water resource [5]. Construction wastewater recycling should be rationally applied to construction enterprises. A substantial volume of wastewater is produced during construction, including ventilation for concrete mixing plants, foundation pit drainage, washing water etc., and enterprises need to carry out the reuse process in a more mature manner. First, wastewater is fed into sedimentation tanks to remove bigger size suspended solids and impurities by means of decantation. This is followed by using filtration equipment for the finer particles. Lastly, treatment for disinfection guarantees the water is suitable for reuse. The treated water is to be used in concrete mixing, wall masonry, construction dust suppression and concrete curing,etc., realizing the recycling mechanism of water resources.

Construction firms working in rainy areas frequently require rainwater harvesting technology. Mainly involving reasonable arrangement of rainwater pipeline and precipitation pool at the construction site, so as to better collect rainwater during rainy season. After simple treatment, the collected rainwater can be used for construction dust suppression, reducing the frequency of watering due to gray dust and for temporary green irrigation, providing water for landscape plants at site, contributing to ecological restoration [6]. In addition, construction enterprises can also install water-saving equipment at home in the process of construction, such as water-saving faucets, toilets and other domestic water equipment and construction machinery with water-saving function. Utilizing these features in the overall approach to water conservation and promoting the development of residential building construction towards a green sustainable direction can also reduce waste from domestic water use and operational water use.

3.3 Application of Energy-Saving and Environmental Protection Wall Technology

As the most important component for enclosing residential buildings, walls significantly affect the energy consumption in the operational phase of buildings thanks to their thermal insulation performance. Construction firms adopting energy-saving and eco-friendly wall technologies at the building site can affect the strain on natural resources for buildings, enhance energy conservation performance from source, and mitigate environmental pollution generated during construction. Construction industry experts have recommended prioritizing the selection of energy-saving materials for walls (autoclaved aerated concrete blocks and thin wall partition panels) when adopting these technologies. These materials provide other benefits, such as low density and low thermal conductivity. Compared to the clay bricks, they will save heat transfer loss via walls and well as the carbon emissions produced in clay resource extraction and firing process which is able to satisfy the concept of green construction. Nonetheless, it is essential to implement the application

of these technologies during construction works with strict control of wall material masonry quality so that the joint does not become excessively large as this will produce too strong a thermal bridging action that impairs insulating efficiency [7].

It is one important link for wall energy efficiency that construction of the insulation layers of walls. The major application directions are external wall insulation (EWI) and internal wall insulation. Extruded polystyrene (XPS) boards and rock wool boards are commonly used insulation materials for EWI. It is built in several stages — base layer treatment, adhesive -> insulation board setting, final rendering (with mortar), & finally application of the finishing layer. In this process, construction personnel are required to pay attention to controlling the firmness of the insulation board adhesion and the thickness of the rendering mortar (≥3mm) to avoid problems such as "detachment" or "cracking" of the insulation layer. Since wall insulation boards are commonly used for internal wall insulation, this study focuses on the thermal energy performance of external well-insulated houses with composite gypsum board. This is highly suitable in northern regions where high heating demand exists every winter and consequently greatly enhancing user thermal comfort indoors. In addition, cold weather construction companies can adopt their own insulation systems for wall construction, which greatly simplify the construction process and improve the construction efficiency, and also facilitate energy-saving effects.

3.4 Application of Energy-Saving Doors and Windows Technology

External doors and windows play an important role in residential buildings as they are often the places where energy is lost. In order to reach a reasonable implementation of energy-saving doors and windows technology in the construction period, it is necessary to optimize building materials selection and installation process, which can significantly decrease the amount of energy consumed by buildings during operation, but also makes doors and windows more durable and safe while providing a better living space atmosphere. Construction companies should choose thermally broken aluminum profiles, Low-E glass and hardware accessories with excellent sealing performance when choosing door and windows materials. The thermally broken aluminum profiles are also superior since a protection (thermal wedge) is inserted into the aluminum alloy profile to considerably reduce the thermal conductivity coefficient of the profile, which means from up to 200 W/(m·K) we can reach: less than 3.0 W/(m·K), effective reducing heat conduction. Low-E glass will reflect and lose a large portion of far-infrared rays, so by using low-E glass doors and windows, the heat transfer coefficient is relatively small, so the performance energy saving effect is better than that of ordinary insulating glass. The use of double- or triple-glazed doors and windows with multi-channel seal systems can also significantly improve tightness to the outside air, and reduce energy loss due to ventilation losses [8].

The installation precision and sealing treatment in the door window phase of construction enterprises will be the first three hats. First of all, laser levels should be used to accurately position the doors and windows so that the vertical deviation does not exceed 3mm in order to avoid seal failure caused by improper installation. While you should fill the gaps between doors/windows and the wall with polyurethane foam, then seal on the outside with weather-resistant sealant and treat on the inside with sealant to create a complete sealing system Construction companies should also set up leveling layers of insulating mortar around door and window openings. This is an effective way to minimize the thermal bridging effect at these areas and further optimize the energy-saving performance of doors and windows, thus enabling residential buildings to make solid stride on the road towards energy efficiency.

4. Conclusion

Incorporating energy-saving and environmental protection technologies in the construction of residential buildings is a significant strategy to combat high energy consumption and high pollution problems within the industry, as well as a critical impetus for advancing low-carbon and green development patterns in construction. These technologies have been proven to improve the efficiency of resource and energy utilization, reduce environmental impact, reconstruct low-carbon

development path of the industry and thus exhibit considerable value. As common technologies in residential construction, solar energy technology, water-saving measures, energy-saving walls (energy-saving doors and windows) are all forcing the industry to greening and energy-saving direction. Driven by the deep integration of intelligent technologies and energy-saving and environmental protection technologies, the future construction sector will enable residential building construction to make new breakthroughs in precise energy saving and smart environmental protection. To make the enterprise department strengthen technology research and development and talent cultivation, optimize application plans based on the actual situation of engineering projects, and actively respond to national policy orientation in order to achieve from "passive application" energy-saving environmental protection technology in a more active direction innovation.

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