

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

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**Abstract:** Driven by both the global energy crisis and the "dual-carbon" goals, various industries have begun to focus on saving energy and strengthening environmental protection. For residential building construction, which generates a significant amount of waste during the construction phase, thereby polluting the surrounding environment, construction companies are increasingly emphasizing the application of energy-saving and environmental protection technologies, viewing them as crucial means for the industry's sustainable development. This article elaborates on the necessity of applying these technologies and explores the specific applications of technologies such as solar energy technology, water-saving technology, energy-saving wall technology, and energy-saving doors and windows technology in residential building construction. The aim is to promote the reconstruction of a low-carbon development path for the construction industry and provide key support for achieving China's green building goals.

## 1. Introduction

With the acceleration of China's urbanization process, the residential building industry has entered a period of rapid development. However, the construction phase of residential building projects faces serious issues of energy consumption and pollution, adversely affecting the ecological environment and residents' quality of life. Under the guidance of the national strategic goals of "carbon peak and carbon neutrality," policy documents such as the "Green Building Evaluation Standard" and the "Civil Building Energy Efficiency Regulations" have been issued, explicitly requiring that residential building construction be incorporated into an energy-saving and environmental protection management system. In this context, exploring the application of energy-saving and environmental protection technologies in residential building construction is not only a practical need to alleviate the energy crisis and improve the ecological environment but also an inevitable choice to promote the transformation of the construction 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

For construction companies, the traditional construction methods used in residential building projects often involve extensive utilization of resources and energy, leading to significant waste. If not improved, this will inevitably exacerbate the global energy crisis. In this context, energy-saving and environmental protection technologies have emerged, providing new pathways to enhance energy utilization efficiency. The use of new energy-saving building materials with good thermal insulation properties in residential construction can reduce energy consumption for heating and cooling. Efficient construction equipment used during construction can lower energy consumption during operation and improve energy use efficiency<sup>[1]</sup>. Furthermore, by optimizing construction processes and reasonably arranging the construction sequence, construction companies can avoid repetitive work and resource idleness, ensuring full utilization of materials, human resources, and

other inputs. Adopting a series of energy-saving and environmental protection technologies not only effectively reduces construction costs but also provides a solid guarantee for the sustainable use of resources, aligning with the needs of long-term social development.

## **2.2 Helps Reduce Environmental Impact**

The dust generated during residential building construction pollutes the air, wastewater discharge contaminates water sources, and construction waste occupies land. Since the construction process can have numerous adverse effects on the surrounding environment, construction companies need to introduce energy-saving and environmental protection technologies to effectively mitigate these problems. Specifically, companies can install water sprinkling systems for dust suppression at the construction site and adopt enclosed construction methods to reduce dust dispersion; establish wastewater treatment systems to treat and recycle construction wastewater or discharge it up to standard, preventing water source pollution; and sort, recycle, and reuse construction waste to reduce landfill volume and the occupation of land resources. Through these measures, the damage to the ecological environment caused by construction activities can be minimized, achieving harmonious coexistence between construction and the environment, and promoting the implementation of the green construction concept.

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

Currently, low-carbon development is advocated globally. As a major consumer of energy and source of carbon emissions, the construction industry should actively transition towards energy saving and environmental protection. The application of energy-saving and environmental protection technologies in residential building construction can provide a new path for the low-carbon development of the construction industry. On one hand, integrating energy-saving concepts from the design stage, planning reasonable building layouts and orientations, and making full use of natural lighting and ventilation can significantly reduce reliance on artificial energy. On the other hand, actively promoting green construction technologies and the utilization of renewable energy sources, such as solar and geothermal energy, encourages the industry to shift from the traditional high-energy-consumption, high-emission model to a low-carbon, environmentally friendly model. This guides the industry to re-examine its development methods and explore a low-carbon development path that meets the requirements of sustainable development<sup>[2]</sup>.

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

## **3.1 Application of Solar Energy Technology**

Solar energy technology, as an energy-saving and environmental protection technology, possesses strong clean and renewable capabilities. Its application in residential building construction can effectively reduce the dependence on fossil fuels, particularly showcasing significant functional advantages in scenarios such as temporary power supply and auxiliary heating. For temporary power supply, the operation of temporary lighting and small equipment on the construction site can be powered by solar photovoltaic (PV) systems. During specific implementation, construction personnel must fully consider the size of the construction site and the electricity demand, scientifically and reasonably configuring key equipment such as solar PV panels, storage batteries, and inverters based on these factors. Solar PV panels are responsible for converting solar energy into electricity, while storage batteries store excess electricity to ensure a stable power supply for construction even under insufficient light conditions, such as during cloudy or rainy weather, preventing construction interruptions due to weather changes<sup>[3]</sup>.

In auxiliary heating scenarios, solar thermal collection systems can provide hot water for construction, meeting the daily needs of construction workers. For winter construction projects in northern regions, construction companies can combine solar air collectors with heating systems to provide warmth for temporary construction dormitories, significantly reducing consumption of fuel

oil and gas, thereby lowering construction costs and environmental impact. Taking concrete curing as an example, traditional curing methods used by construction companies during winter often require extensive use of electric heating equipment to maintain the temperature of the curing water, resulting in high energy consumption<sup>[4]</sup>. Using solar heating systems can precisely control the temperature of the curing water between 15–20°C. This not only reduces the energy consumption of electric heating equipment but also, due to the suitable temperature, enhances the development speed of concrete strength, shortening the curing period by 3–5 days, effectively improving construction efficiency, and ensuring project quality.

### **3.2 Application of Water-Saving Technology**

Water consumption during residential building construction is extremely high. To conserve water resources, construction companies need to rationally employ water-saving technologies. The application focus of this technology mainly concentrates on three aspects: recycling construction wastewater, rainwater collection and utilization, and configuring water-saving equipment. Construction companies need to comprehensively utilize these technologies to improve the efficiency of construction water usage, effectively alleviate water shortage issues during construction, and reduce water resource consumption costs<sup>[5]</sup>. Construction companies should prioritize the rational application of construction wastewater recycling technology. Since large amounts of wastewater are generated during construction, such as from concrete batching plants, foundation pit dewatering, and washing water, companies need to establish a mature treatment and recycling process for this wastewater. First, wastewater is directed into sedimentation tanks to remove larger suspended solids and impurities through sedimentation. Then, filtration equipment is used for further filtration to remove finer particles. Finally, disinfection treatment ensures the water quality meets reuse standards. The treated water can be used for various purposes, including concrete mixing, wall masonry, construction dust suppression, and concrete curing, thereby achieving the recycling of water resources.

Construction companies operating in rainy regions often need to utilize rainwater collection technology. This primarily involves reasonably setting up rainwater pipelines and collection pools around the construction site to effectively collect rainwater during the rainy season. The collected rainwater, after simple treatment, can be used for construction dust suppression, reducing the need for additional watering due to dust, and can also be used for temporary green irrigation, providing water for green plants on the construction site and promoting ecological improvement<sup>[6]</sup>. Additionally, construction companies should also install water-saving equipment during construction, such as water-saving faucets, toilets, and other domestic water fixtures, as well as construction machinery with water-saving functions. Leveraging these features can reduce waste in both domestic and operational water use, further enhancing water conservation efforts and promoting the development of residential building construction towards a green and sustainable direction.

### **3.3 Application of Energy-Saving and Environmental Protection Wall Technology**

Walls, as the main enclosure structure of residential buildings, have a decisive impact on the energy consumption during the building's operational phase due to their thermal insulation performance. The application of energy-saving and environmental protection wall technologies during the construction phase by construction companies can not only improve the building's energy efficiency from the source but also effectively reduce the negative environmental impact of construction. In specific construction practice, when applying these technologies, companies should prioritize the selection of energy-saving materials for walls, such as autoclaved aerated concrete (AAC) blocks and lightweight partition panels. These materials offer advantages like low density and low thermal conductivity. Compared to traditional clay bricks, they can reduce heat transfer loss through walls while also lowering carbon emissions generated during clay resource extraction and firing processes, aligning with the green construction concept. However, when applying these technologies during construction, it is crucial to strictly control the masonry quality of wall materials to prevent excessively large mortar joints from causing a thermal bridging effect, which

would compromise insulation performance<sup>[7]</sup>.

The construction of wall insulation layers is a key link for wall energy efficiency. External wall insulation (EWI) and internal wall insulation are the main application directions. EWI commonly uses insulation materials like extruded polystyrene (XPS) boards and rock wool boards. The construction process involves multiple steps, including base layer treatment, adhesive layer application, insulation board installation, rendering with mortar, and finishing layer application. During this process, construction personnel must focus on controlling the firmness of the insulation board adhesion and the thickness of the rendering mortar (needs to be  $\geq 3\text{mm}$ ) to avoid issues like detachment or cracking of the insulation layer. Internal wall insulation often uses gypsum board composite insulation layers, particularly suitable for northern regions with high heating demands in winter, significantly improving indoor thermal comfort. Furthermore, construction companies can also adopt self-insulation systems during wall construction, which can further simplify the construction process, improve construction efficiency, and enhance overall energy-saving effects.

### **3.4 Application of Energy-Saving Doors and Windows Technology**

Doors and windows are crucial components of residential buildings and are key areas for energy loss. The rational application of energy-saving doors and windows technology during the construction stage requires optimizing material selection and installation processes to effectively reduce energy consumption during the building's operational phase, enhance the durability and safety of doors and windows, and thereby create a more comfortable and energy-efficient indoor environment for occupants. When selecting door and window materials, construction companies should prioritize thermally broken aluminum profiles, Low-E glass, and hardware accessories with excellent sealing performance. Thermally broken aluminum profiles have a unique advantage: by incorporating a thermal barrier within the aluminum alloy profile, the thermal conductivity coefficient of the profile can be significantly reduced from around  $200 \text{ W}/(\text{m}\cdot\text{K})$  to below  $3.0 \text{ W}/(\text{m}\cdot\text{K})$ , greatly minimizing heat transfer. Low-E glass can reflect a large amount of far-infrared radiation, effectively reducing the heat transfer coefficient of doors and windows, offering better energy-saving performance compared to ordinary insulating glass. Using doors and windows with multi-channel sealing structures can also substantially improve air tightness, reducing energy loss caused by air infiltration<sup>[8]</sup>.

During the door and window installation phase, construction companies must focus on controlling installation precision and sealing treatment. On one hand, companies should use laser levels to accurately calibrate the position of doors and windows, ensuring that vertical deviation does not exceed  $3\text{mm}$  and horizontal deviation does not exceed  $2\text{mm}$ , preventing seal failure due to improper installation. On the other hand, the gaps between doors/windows and the wall should be filled with polyurethane foam, sealed on the exterior with weather-resistant sealant, and treated on the interior with sealant to build a complete sealing system. Additionally, construction companies should install leveling layers of insulating mortar around door and window openings. This can effectively reduce the thermal bridging effect at these locations, further enhancing the energy-saving performance of doors and windows, allowing residential buildings to take solid steps on the path to energy efficiency.

## **4. Conclusion**

The application of energy-saving and environmental protection technologies in residential building construction is a key measure to address the industry's issues of high energy consumption and high pollution, and it serves as a core driving force for promoting the transformation of the construction industry towards low-carbon and green development. The application of these technologies has demonstrated strong value in improving resource and energy utilization efficiency, reducing environmental impact, and reconstructing the industry's low-carbon development path. Technologies such as solar energy, water-saving measures, energy-saving walls, and energy-saving doors and windows, as commonly used technologies in residential construction, are pushing the industry towards greening and energy efficiency. In the future construction sector, with the deep

integration of intelligent technologies and energy-saving and environmental protection technologies, residential building construction will achieve new breakthroughs in precise energy saving and smart environmental protection. Construction companies must further strengthen technology research and development and talent cultivation, optimize technology application plans based on actual project needs, and actively respond to national policy directions to promote the shift from "passive application" to "active innovation" in energy-saving and environmental protection technologies.

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