Energy Conservation Management Technology and Practice of Mechanical and Electrical Engineering under the Background of Green Buildings

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Abstract: The concept of green construction runs through the entire life cycle of buildings. The energy consumption of mechanical and electrical systems accounts for a prominent proportion of the overall energy consumption of buildings. The traditional extensive equipment operation and maintenance and pipeline layout mode is prone to cause continuous energy loss and is difficult to meet the long-term development needs of low-carbon construction. Mechanical and electrical engineering encompasses multiple systems such as HVAC, water supply and drainage, and strong and weak electricity. The operating conditions of each device are interrelated. Any oversight in the control of a single link will amplify the overall energy consumption level. This article focuses on three fundamental theories: the full-cycle energy balance of green buildings, the coordinated energy consumption regulation of mechanical and electrical systems, and the refined operation and maintenance management of building mechanical and electrical systems. It sorts out the common energy consumption control shortcomings in the current mechanical and electrical construction and operation and maintenance stages A complete set of implementation paths is established from four aspects: the design of an integrated energy-saving solution in the early stage, the optimization and layout of on-site mechanical and electrical pipelines, the intelligent time-sharing control and operation and maintenance of equipment, and the closed-loop management of energy consumption throughout the entire process. This is to reduce the ineffective energy loss of building mechanical and electrical systems and simultaneously enhance the stability of low-carbon operation of green buildings. Provide feasible technical management support for the construction and operation and maintenance of green mechanical and electrical engineering in various civil and public buildings.
***Keywords*:** Green building Mechanical and Electrical engineering Energy conservation management Energy consumption regulation Green construction

1. Introduction

Under the guidance of low-carbon development, all new and renovated buildings are implementing green construction standards. The long-term continuous operation of mechanical and electrical equipment leads to stable energy consumption. Unreasonable pipeline layout, disorderly equipment operation scheduling, and loose daily operation and maintenance management will all exacerbate energy waste. Sorting out the key contents of energy-saving control throughout the entire chain of mechanical and electrical engineering, from scheme design, on-site installation to later operation and maintenance, and establishing a refined management model that is compatible with the green building evaluation standards can continuously reduce the ineffective energy consumption of buildings and promote the smooth implementation and promotion of the relevant technical system of green construction. The building mechanical and electrical system is the core carrier for the output of building energy consumption and also the key handle for the low-carbon transformation of green buildings. In the process of green transformation of the industry, the quality of energy-saving control in mechanical and electrical engineering directly determines the overall low-carbon compliance level of buildings. A standardized and systematic energy-saving management model is the core support for promoting the green upgrade of the construction industry.

2. Basic theories related to mechanical and electrical energy conservation in green buildings

Building energy consumption is not only concentrated in the stage of completion and commissioning. The selection of mechanical and electrical schemes in the early stage, on-site pipeline construction, and long-term equipment operation and maintenance can all change the overall energy revenue and expenditure situation. The core of the full-cycle energy balance theory is to coordinate the energy input and loss throughout the entire stage of building construction and use. Under the premise of meeting the indoor usage functions, it reduces various irreversible energy wastes, and at the same time takes into

account the access of renewable energy, waste heat recovery and other gain measures to maintain the overall energy supply and demand balance of the building.

The entire set of theories breaks the one-sided thinking that only focuses on energy conservation of equipment after it is put into use, extending the energy conservation control requirements to the entire chain of design, construction and operation and maintenance. It provides the underlying logical support for the formulation of energy conservation plans for green building mechanical and electrical integration and the full-process energy consumption control, achieving the two-way compatibility of building usage functions and low-carbon operation goals. Traditional building energy consumption management mostly focuses on the operation and maintenance stage after the building is completed, while neglecting the inherent energy consumption defects formed in the design and construction stages. The theory of full-cycle energy balance is based on the entire life cycle of buildings, discarding the one-sided and phased energy-saving control thinking, and achieving effective connection of energy-saving control at each stage, which is in line with the development needs of long-term low-carbon operation of modern green buildings [1].

The theory replaces the annual static energy consumption statistics with regular dynamic energy consumption monitoring, providing core guidance for establishing a green building mechanical and electrical complete set energy-saving operation and maintenance management system, and ensuring that the mechanical and electrical system maintains a low-loss operation state for a long time. The energy consumption loss of mechanical and electrical equipment has the characteristics of continuity, gradualness and concealment. The conventional static verification mode is difficult to capture the subtle energy consumption risks. The theory of refined operation and maintenance control relies on a regular and comprehensive verification mechanism to achieve early detection and prompt handling of energy consumption risks, prevent the long-term accumulation of minor losses that could lead to large-scale energy waste, and ensure the long-term stable and low-carbon operation of the electromechanical system [2].

3. There are still prominent shortcomings in the energy conservation control of mechanical and electrical engineering in green buildings

For some projects, the mechanical and electrical schemes have only completed the design of HVAC, power, and water supply and drainage specialized drawings separately, without conducting multi-system collaborative energy consumption simulation calculations. The equipment selection only refers to the conventional usage requirements and does not match energy-saving models in combination with the local meteorological characteristics throughout the year. The pipeline layout only takes into account the convenience of construction, lacking optimization ideas for shortening the transportation distance and reducing cold and heat loss. Design flaws such as long-distance pipelines without insulation and pipeline intersections and detours are widespread.

During the design stage of the scheme, the supporting points for renewable energy such as photovoltaic and waste heat recovery were not included simultaneously. The addition of energy-saving equipment in the later renovation will significantly increase the construction and renovation costs. The design drawings lack a multi-disciplinary joint energy-saving review process, and various energy consumption risks cannot be eliminated in advance before the construction starts, which will raise the long-term operating energy consumption level of the building from the source. At present, most building mechanical and electrical designs still follow the traditional independent design model by specialty. The design standards and energy-saving targets of each specialty are not unified, making it impossible to form a collaborative energy-saving design system. The lack of energy-saving coordination in the design stage will result in inherent energy consumption defects in the building's mechanical and electrical systems, significantly compressing the space for energy-saving optimization in the subsequent construction and operation and maintenance stages.

4. Implementation path for complete energy-saving management of mechanical and electrical engineering that conforms to green building standards

4.1 Improve the coordination mechanism for multi-disciplinary joint pre-energy-saving plans

During the formal mechanical and electrical scheme design stage, HVAC, power, and water supply and drainage professionals were simultaneously organized to conduct a joint energy-saving review. Relying on local meteorological parameters throughout the year, multi-system collaborative energy consumption simulation calculations were completed, and corresponding energy-saving equipment units were matched. Optimize the overall pipeline layout, minimize the transportation distance of cold and hot media to the greatest extent, avoid long-distance circuitous pipeline arrangement, and uniformly set the minimum thickness of the insulation layer and the hard standards for complete coverage of the sealed vapor barrier.

At the same time, reserve the supporting layout points for renewable energy such as photovoltaic and waste heat recovery, incorporate the utilization of renewable energy into the initial plan framework, and prevent large-scale renovation and adjustment in the later stage. Complete the archiving of energy consumption simulation reports and multi-disciplinary review records as the prerequisite materials for the distribution of construction drawings, eliminating the original energy consumption risks at the pipeline and equipment levels from the design source, and establishing an integrated energy-saving design control front line. Through the multi-disciplinary collaborative review model, the energy-saving design standards of each system can be unified, the barriers of specialized design can be broken, and the equipment selection and pipeline layout can be optimized in combination with the building usage scenarios and regional climate characteristics. This can solve the inherent energy consumption defects from the root and lay a solid foundation for subsequent construction and operation and maintenance energy conservation [4].

4.2 Unify the standardized construction operation details for energy conservation of on-site mechanical and electrical pipelines

Compile the complete set of construction specifications for green building mechanical and electrical pipelines, clearly defining the full set of rigid process standards for insulation, sealing and vapor barrier, and regular layout of cold and hot medium pipelines. All on-site teams must strictly follow the detailed rules to complete the laying work. After the cold and hot transportation pipelines are laid, they should be immediately and completely wrapped with insulation materials. The joints and gaps should be sealed with special sealing fillers to prevent the cold and hot media from coming into direct contact with the external air and causing losses.

Unify the pipeline layout standards for multiple specialties, and arrange the strong and weak current, water supply and drainage, and HVAC pipelines in an orderly and layered manner to reduce unnecessary bends and long-distance cable extensions, and lower the flow resistance of the medium and the power loss of the lines. During the construction process, dedicated personnel are assigned to supervise the implementation of energy-saving procedures. Issues such as missing insulation and circuitous pipelines are immediately rectified before proceeding to the next step. Standardized construction is relied upon to reduce continuous energy loss during the pipeline transportation stage.

5. Conclusion

The long-term low-carbon operation goal of green buildings puts forward higher requirements for the energy-saving control of the entire chain of mechanical and electrical engineering. The mature theories related to the full-cycle energy balance of green buildings, the coordinated energy consumption regulation of mechanical and electrical systems, and the refined operation and maintenance control of mechanical and electrical engineering provide clear theoretical support for clarifying the sources of various energy consumption losses and establishing a complete energy-saving management system. At present, there are prominent shortcomings in mechanical and electrical engineering, such as insufficient energy-saving coordination in the pre-planning, lack of energy-saving norms in pipeline construction, rough equipment control, and absence of closed-loop management of energy consumption throughout the entire process. These issues continue to cause irreversible energy waste at the pipeline transportation and equipment operation levels.

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