

Research on Energy Saving Management Models for Coal-Fired Power Plants in the Context of New Energy

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Keywords: New Energy Context; Coal-Fired Power Plants; Management Models

Abstract: With the increasing severity of global climate change and environmental issues, the development of new energy has become an essential part of the energy strategy of various countries. New energy technologies, characterized by their cleanliness and renewability, are gradually replacing traditional energy sources, shaping the future trend of energy development. In this context, coal-fired power plants, representing a traditional energy industry, are facing immense pressure and challenges. To address these challenges, coal-fired power plants need to actively explore and implement energy-saving management models, improve energy efficiency, and reduce environmental pollution, adapting to the trend of new energy development. This involves optimizing the energy structure and integrating new energy generation technologies to progressively reduce the proportion of coal-fired power generation, thereby decreasing carbon emissions and energy consumption. Furthermore, coal-fired power plants should utilize advanced technology and equipment to enhance coal combustion efficiency and reduce energy wastage in production processes. The transformation process requires coal-fired power plants to actively adapt, adopting effective energy-saving management models to align with the trend of new energy development. Over time, this will enhance the competitiveness and sustainability of coal-fired power plants, promoting the optimization of China's energy structure and advancements in environmental protection.

1. The Role of Coal-Fired Power Plants in the Current Energy Structure

Coal-fired power plants hold a significant position in the current energy structure. Despite the rapid development of renewable energy, coal remains an irreplaceable source of energy due to its stability. Compared to renewable sources like solar and wind energy, coal mining and utilization technologies are well-established and offer higher energy density, ensuring stable supply over extended periods. Hence, coal is a reliable energy guarantee, especially when energy demands are high. Coal-fired power plants play a crucial role in electricity supply. Currently, China's electricity supply is primarily based on thermal power, with coal-fired plants being a major component. Amidst growing electricity demand, these plants can quickly and conveniently meet the power requirements, ensuring the stability of the electricity system. Coal also has strategic importance in China's energy structure, with the country being rich in coal resources^[1]. The development of coal-fired power plants has bolstered the coal industry, promoting employment and economic

growth. However, these plants also face challenges in environmental protection and energy efficiency. Future development must focus on technological innovation and environmental governance to enhance the efficiency and environmental standards of coal-fired power plants, meeting the needs of energy structure adjustments.

2. The Impact of New Energy on Coal-Fired Power Plants

2.1 Influence on the Energy Market

With the continual rise in energy demand due to socio-economic development and population growth, and the increasing severity of environmental pollution and supply pressure from traditional energy sources, countries worldwide are promoting new energy development for sustainable energy growth. New energy is becoming increasingly important in the energy market. On one hand, technological advancements and cost reductions have made new energy more competitive, challenging traditional energy sources. On the other hand, governments are enacting policies to encourage new energy development and reduce reliance on fossil fuels to combat climate change. The growth of new energy has profoundly impacted coal-fired power plants. As new energy sources are clean and renewable, they have become significant in the energy market, squeezing the market share of coal-fired power plants and increasing their competitive pressures. Additionally, the development of new energy compels coal-fired power plants to upgrade technologies and reform operations to reduce environmental pollution and enhance energy efficiency. Moreover, the rise of new energy markets diversifies energy supply, reducing dependence on traditional energy sources. This transition promotes a more sustainable and environmentally friendly energy market development, driving technological innovation and economic benefits in the energy industry.

2.2 Impact on the Electricity Market

The global demand for energy and the growing awareness of environmental protection have made the development of new energy an inevitable trend. The application of new energy has not only deeply influenced coal-fired power plants but also significantly impacted the entire electricity market, as shown in Table 1. First, the rise of new energy increases the supply of renewable energy, disrupting the traditional balance of power supply and demand. This leads to a decrease in demand for traditional electricity, prompting structural adjustments in the electricity market. Second, the development of new energy diversifies the electricity supply, breaking the monopoly of the traditional power industry. Investments in various new energy sources expand the scale of the electricity market, fostering a more diverse market development. Third, the advantages of new energy, such as being clean and renewable, along with technological progress and cost reductions, have made it a major force in the energy market. This accelerates the transition of the electricity market towards cleaner and lower-carbon directions. Fourth, the variability and uncertainty of new energy pose higher demands on the operation and management of the power grid. The electricity market needs to adapt to the characteristics of new energy, strengthening the operational management of the power grid to ensure stability and reliability. Fifth, the development of new energy influences the pricing system of the electricity market^[2]. As the costs of generating new energy decrease, it puts competitive pressure on traditional energy sources, leading to price fluctuations in the electricity market. The widespread and profound impact of new energy on the electricity market requires collaborative efforts from all parties to promote sustainable market development.

Table 1: The Impact of New Energy on the Electricity Market

Impact Aspects	Specific Impacts
Supply and Demand Relationship	The increase in new energy supply disrupts the traditional balance of power supply and demand, leading to a decline in demand.
Market Diversification	Investment and construction in new energy expand market size, breaking the monopoly of the traditional electric power industry and leading to market diversification.
Energy Transition	New energy, as a major force of clean and renewable energy, drives the power market towards a cleaner and low-carbon transformation.
Grid Operation and Management	The variability and uncertainty of new energy impose higher demands on grid scheduling and operation, necessitating strengthened grid operation and management.
Price Fluctuations	The reduced cost of new energy creates competitive pressure on traditional energy sources, leading to price fluctuations in the power market.

3. Energy Saving Management Models for Coal-Fired Power Plants in the New Energy Context

3.1 Adjusting the Energy Structure

With the intensification of the global energy crisis and environmental issues, the development of new energy has become a focal area for governments and enterprises worldwide. As the world's largest energy consumer, China faces dual pressures of energy structure adjustment and environmental protection. Faced with the rise of new energy, coal-fired power plants need to gradually reduce their dependence on coal and diversify their energy supply. By constructing new energy projects such as solar and wind power, these plants can reduce carbon emissions and lessen environmental pollution. Additionally, integrating with renewable energy sources can bring more development opportunities for these plants, helping them better integrate into the new energy industry chain. Coal-fired power plants need to continually introduce and adopt advanced clean coal technologies to improve the efficiency of coal-fired power generation and reduce pollutant emissions^[3]. For example, the application of supercritical and ultra-supercritical technologies can reduce energy consumption and pollutant emissions during coal combustion, enhancing energy use efficiency. Also, promoting clean coal technologies like coal washing and briquetting can further reduce harmful substances in coal, minimizing environmental pollution. Coal-fired power plants can improve energy recovery rates through measures like waste heat recovery and flue gas waste heat utilization. By recycling the emitted waste heat, not only can energy wastage be reduced and the company's energy consumption costs lowered, but it can also create additional economic benefits. This approach aligns with the concepts of energy-saving, emission reduction, and sustainable development.

3.2 Optimizing Unit Operation

Optimizing the operation of units in coal-fired power plants is crucial for improving energy efficiency and reducing emissions. Using advanced dispatching and optimization algorithms to make intelligent decisions based on grid load conditions and unit status can help arrange operation

modes and start-up times of units, as detailed in Table 2. First, dynamic dispatching based on grid load demand is key. Coal-fired power plants need to work closely with grid dispatch departments, monitor changes in grid load in real-time, and adjust unit start-up and output based on load demands. Proper dispatching ensures that units operate in high load areas, enhancing power generation efficiency and avoiding energy wastage in low load areas. Secondly, optimizing unit operation parameters is also important. By finely tuning the operating parameters of key equipment like boilers and turbines, the thermal efficiency of units can be further improved. This involves optimizing critical parameters like main steam temperature, main steam pressure, and feedwater temperature to ensure units operate under optimal conditions. Moreover, strengthening the coordinated operation management of units is a necessary measure. For coal-fired power plants with multiple parallel units, it is essential to reasonably allocate the output of each unit to avoid inefficiencies. Optimizing allocation can fully utilize the advantages of the unit cluster, improving overall operational efficiency. Finally, introducing intelligent technologies can enhance the effectiveness of unit operation optimization. Using advanced technologies like big data analytics and artificial intelligence to monitor and mine unit operation data in real-time can uncover potential optimization areas and support dispatch decisions. The application of intelligent technologies enables adaptive adjustment and intelligent optimization of unit operation modes.

Table 2: Contents and Descriptions of Optimizing Unit Operation

Number	Optimization Contents	Descriptions
1	Dynamic Scheduling	Adjust the operation mode and start-up time of units in real time according to the grid load demand.
2	Optimization of Operating Parameters	Finely adjust the operating parameters of key equipment such as boilers and turbines to achieve optimal operating conditions.
3	Coordinated Operation Management of Units	Reasonably allocate the output of multiple units to avoid resource waste and improve overall operational efficiency.
4	Application of Intelligent Technologies	Utilize technologies like big data analysis and artificial intelligence to monitor and mine unit operation data in real time, identifying areas for optimization.

3.3 Implementing Technological Transformations

Implementing technological transformations is one of the key methods for coal-fired power plants to save energy and reduce emissions. With the continuous development of technology, new techniques and equipment are emerging, offering more possibilities for energy saving and emission reduction in coal-fired power plants. Firstly, adopting advanced combustion control technology can improve the efficiency of boiler combustion, reducing energy waste and emissions caused by incomplete combustion. For example, intelligent combustion control technology can optimize boiler combustion parameters in real-time, ensuring full fuel combustion and enhancing efficiency while also reducing the carbon content in slag and emission of toxic substances^[4]. Secondly, advanced emission control technologies can effectively reduce pollutant emissions from coal-fired power

plants. Technologies like flue gas desulfurization and denitrification can remove sulfur oxides and nitrogen oxides from flue gases through chemical or physical methods, reducing environmental pollution. These technologies significantly lower the emission of pollutants like sulfur dioxide and nitrogen oxides, improving air quality. Thirdly, employing efficient water treatment technology is also a crucial aspect of technological transformation in coal-fired power plants. Proper treatment and utilization of water resources can reduce water consumption and wastewater discharge. For instance, reverse osmosis technology can effectively remove impurities and salts from water, enhancing water utilization efficiency and reducing wastewater discharge, thereby easing the environmental burden.

3.4 Strengthening Equipment Maintenance

Stable operation of equipment is directly related to energy efficiency and pollutant emissions, thus maintenance should not be taken lightly. To ensure equipment is in good operating condition, a comprehensive maintenance system must be established. This system should include regular inspections, maintenance, repairs, and real-time monitoring and management of equipment operation. By implementing preventative and predictive maintenance, potential issues can be identified and resolved timely, avoiding energy waste and increased emissions due to equipment failures. Moreover, enhancing the skill level and sense of responsibility of maintenance personnel is crucial. Regular training and incentive mechanisms can ensure that maintenance staff accurately assess equipment conditions and take effective measures for maintenance and repair. Additionally, strengthening collaboration and communication with equipment manufacturers and technical service providers is an important way to enhance maintenance. Collaboration with these professionals can provide more expert maintenance advice and technical support, resolving challenges in equipment maintenance. Establishing emergency response plans for equipment failures is also essential, developing contingency plans and repair measures for potential failures to ensure rapid response and repair in case of incidents. Such plans can improve the rapid response capability of equipment maintenance, minimizing the impact of equipment failures on energy efficiency and emissions.

3.5 Enhancing Employee Competency

Improving the quality of employees is a crucial safeguard for achieving energy-saving and emission reduction targets in coal-fired power plants. Employees' skills and awareness largely determine the enterprise's energy utilization efficiency and pollutant emission levels. Therefore, training and educating employees is vital. To raise employees' awareness of energy conservation and emission reduction, promotional and educational activities should be conducted, making them fully aware of the importance and urgency of these initiatives and their contributions to the enterprise and society. Guiding employees to adopt a green development concept, cultivating their environmental consciousness and sense of social responsibility, and inspiring their enthusiasm and initiative in energy-saving and emission reduction are also important. Moreover, enhancing employees' skills through training is essential. Organizing regular skill training courses and inviting experts to teach can equip employees with advanced energy-saving and emission reduction technologies and equipment operation skills^[5]. Training helps employees accurately assess equipment operation, timely identify and resolve potential issues, and improve equipment operation efficiency and stability. Training can also foster employees' innovative abilities and problem-solving skills, providing more talent support for the enterprise's energy-saving and emission reduction efforts. By strengthening employee education, skill training, and other measures, employee awareness and skill levels in energy conservation and emission reduction can be further enhanced,

promoting sustainable development of the enterprise. Attention should also be paid to employees' growth and development, offering more learning and promotion opportunities, and cultivating a high-quality, specialized workforce for energy-saving and emission reduction.

4. Conclusion

With the rapid development and widespread application of new energy technologies, coal-fired power plants, as part of the traditional energy industry, face significant challenges and opportunities. To adapt to this transformation, coal-fired power plants need to actively explore and implement energy-saving management models to reduce energy consumption, enhance energy utilization efficiency, and decrease environmental pollution. This is not only necessary for the sustainable development of enterprises but also a positive contribution to global energy transition and climate change response. Optimizing the energy structure is a crucial direction for energy-saving management in coal-fired power plants. Reducing the proportion of coal-fired power generation and increasing the share of new energy generation can lessen dependence on fossil fuels and lower carbon emissions, thereby better protecting the environment. At the same time, this brings new development opportunities for enterprises, enabling them to integrate more effectively into the new energy industry chain. Additionally, by introducing efficient and environmentally friendly coal combustion technologies and equipment, coal-fired power plants can improve coal combustion efficiency, reduce energy consumption, and decrease pollutant emissions. Only through continuous exploration and practice can the most suitable energy-saving management models be found, promoting the green transformation and sustainable development of the energy industry and contributing to building a better future.

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