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EDITED BY
Yanan Gao,
China University of Mining and Technology, China

REVIEWED BY
Chun Zhu,
Hohai University, China
Huining Ni,
China University of Mining and Technology, China
Wang Qun,
Taiyuan University of Technology, China
Jiliang Pan,
University of Science and Technology Beijing, China

*CORRESPONDENCE
Chen Li,
leesin0225@163.com

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Research on top-level planning for sustainable high-quality development of China's largest scale deep coal mining area

Delin Xin[1], Chen Li[1]*, Tuantuan Chen[1], Xinying Fang[2], Qiang Zhao[1] and Hu Chen[1]

[1]CCTEG Wuhan Engineering Company, Wuhan, China, [2]School of Marxism, China University of Geosciences, Wuhan, China

Coal is the dominant energy source in China, as it has an advantageous position in terms of resource distribution. Against the backdrop of China's high-quality economic development and the global energy crisis, after nearly a decade of preparation, the Xinjie Taigemiao Mine Area (XTMA) has entered the substantial planning and design stage. Based on the resource development conditions and the background of the times of XTMA, the paper provides an in-depth analysis of the connotation and characteristics of XTMA's high-quality development. Subsequently, the overall development concept of "1358" for XTMA is proposed, which includes one strategic objective, three new models, five attribute goals, and eight assessment indicators. Based on this, a top-level planning and design for the implementation of high-quality development in XTMA is carried out comprehensively from aspects such as spatial layout, intelligent safety, integrated zero-carbon, ecological green, technological innovation, cluster management, and harmonious happiness. Finally, we look forward to the long-term blueprint for high-quality development of the XTMA and put forward urgent recommendations for current construction. The research on the high-quality development plan of XTMA will promote the development of China's coal industry and is of great significance.

KEYWORDS

Xinjie Taigemiao Mine Area, high quality development, planning and design, development philosophy, implementation path

1 Introduction

China's resource conditions have the characteristics of "rich coal, poor oil, and little gas," which leads to a significant proportion of coal in China's primary energy consumption. In 2022, it still accounted for approximately 56% (Kang et al., 2019; Xie et al., 2021a). Therefore, coal bears an important responsibility in ensuring national energy security and stable supply (Wu et al., 2019; Hou et al., 2022). The 20th National People's Congress of the Communist Party of China proposed that "actively and steadily promote carbon peak carbon neutrality, and further promote the energy revolution..." In the new era, China's energy development needs to actively adapt to the new development requirements of the domestic and international situation. It is of great significance to firmly adhere to a new path of high-quality development and focus on the present and the long term (Fu and Xiao, 2021).

Many experts and scholars have put forward constructive views on the high-quality development of the coal industry. Wang (2018) summarizes and reviews the achievements of the coal industry over the past 40 years since the reform and opening up, objectively analyzes the current situation and trends of the coal economy, and plans the next work requirements for the coal industry. Wang et al. (2019a), Wang et al. (2020a), and Wang (2022) put forward the overall requirements and construction goals of coal mine intellectualization for high-quality development of coal industry, and carried out the top-level design of coal mine intellectualization. Niu (2019) and Niu (2021) studied the focus of high-quality development in the industry from six dimensions based on current forms and policies, and discussed the practical significance of high-quality development in coal enterprises. Li (2019) and Kang et al. (2021) have planned key tasks for high-quality development of the industry in response to three imbalanced and six insufficient issues in industry development, combined with the new requirements of energy development in the new situation. Jin et al. (2020) analyzed the stress characteristics of regional industrial development on the ecological environment background, atmospheric environment, water resources and water environment, and ecological functions, and summarized the main contradictions and relationships that need to be grasped between regional industrial development and ecological environment protection. Liu et al. (2021) and Liu et al. (2022) summarized the main achievements of China's coal technology since the 13th Five Year Plan and clarified the main tasks of "31110" scientific and technological innovation, which has guiding value for the high-quality development of coal technology during the 14th Five Year Plan. Li et al. (2021) proposed 29 specific paths from 5 dimensions to achieve high-quality development of the coal industry. Liu et al. (2021) and Jia et al. (2022) defines the connotation of high-quality development of coal industry, constructs the evaluation index system of basic capacity of high-quality development of coal industry. Lin (2022) based on China's national conditions analyzes the scenario of carbon peak in 2030. Yuan (2023) systematically summarized significant technological innovation achievements in six aspects and clarified four future innovation directions for high-quality development, pointing out the direction for high-quality coal development.

The development of XTMA is a key project of the country and is fully equipped to be developed by the China Energy Investment Corporation (CHN Energy). The exploration, planning, design, and development of the mining area are carried out by the Shenhua Xinjie Energy Co., Ltd. (Xinjie Energy) of the CHN Energy (Xin et al., 2020). How can we implement the concept of high-quality development, transform the allocation of coal resources, and develop coal resources intensively and efficiently through comprehensive planning, top-level design, and early layout? This is a major practical problem that urgently needs to be solved (Li, 2019; Kang et al., 2021; Li et al., 2021). Therefore, it is urgent to combine the characteristics of the mining area and the requirements of the times to clarify the development connotation, overall development concept, and construction route of the mining area. This is crucial to the high-quality development of XTMA and even China's coal industry.

Based on extensive literature reviews, we found that previous research has mostly focused on individual insights of expert scholars or, in other words, macro-level outlooks on future prospects. This paper is set against the backdrop of an actual mining area under construction, and its research results will directly guide the development and construction of the mining area. Compared to macro-level planning, it is more feasible, and compared to design, it is more exploratory. This paper is an organic integration of planning, research, and design, which makes it more practically significant in comparison.

2 XTMA high quality development background

2.1 Overview of XTMA basic conditions

XTMA is located in Ordos City, Inner Mongolia Autonomous Region, and its resources belong to the Dongsheng Coalfield. The total planned area of XTMA is 681.03 km^2, with a coal resource of approximately 12.298 billion tons. There are 15 minable coal seams with a burial depth of 520–920 m. XTMA coal seam has stable occurrence, excellent coal quality, simple mining technology conditions, and is suitable for large-scale mechanized mining. XTMA plans to construct eight coal mines with a total production capacity of 56.00 Mt/a. The construction timeline of XTMA planning is shown in Figure 1.

Ordos, where XTMA is located, is located at the northern end of the national "two horizontal and three vertical" urbanization strategy pattern, with a complete transportation network and supporting industrial system. The spatial location is shown in Figure 2. As the world's largest coal production company, thermal power generation company, wind power generation company, and coal-to-oil and coal-to-chemicals company, CHN, who is responsible for implementing the development of XTMA, has strong technological and financial advantages. At the same time, XTMA also faces unfavorable factors such as deep strong strata behaviors (Yin et al., 2021; Zhu et al., 2021), overlapping mining rights (coal and natural gas), rock burst (Tang and Tang, 2012; Qin et al., 2023; Ren et al., 2023), and ecological fragility (Zhang et al., 2019; Wang et al., 2020b; Cai et al., 2020).

2.2 The connotation and characteristics of XTMA high quality development

XTMA's high-quality development needs to be based on a new stage of development, implement new development concepts, and construct a new development pattern. Therefore, based on the actual situation of the XTMA, we have defined its connotation of high-quality development, as described below (Fu and Xiao, 2021; Jia et al., 2022).

Starting from the perspective of the full life cycle of the mining area, we must adhere to the principle of ecological priority and green development. We must adhere to the people-centered approach and insist on high-start planning, high-standard construction, and high-quality development. We will stimulate endogenous motivation through technological innovation, promote production-sales balance through intensive and efficient measures, enhance quality and efficiency through safety and intelligence, enhance development vitality through zero-carbon and green initiatives, and achieve open sharing through

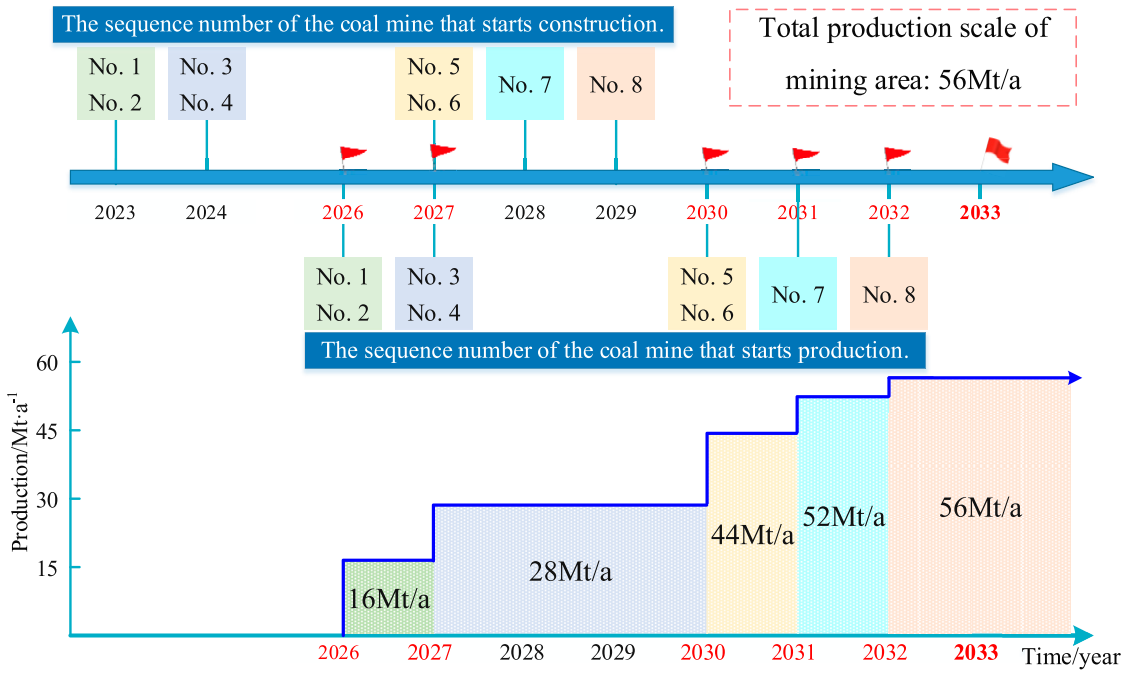

FIGURE 1
Construction timeline of XTMA planning.

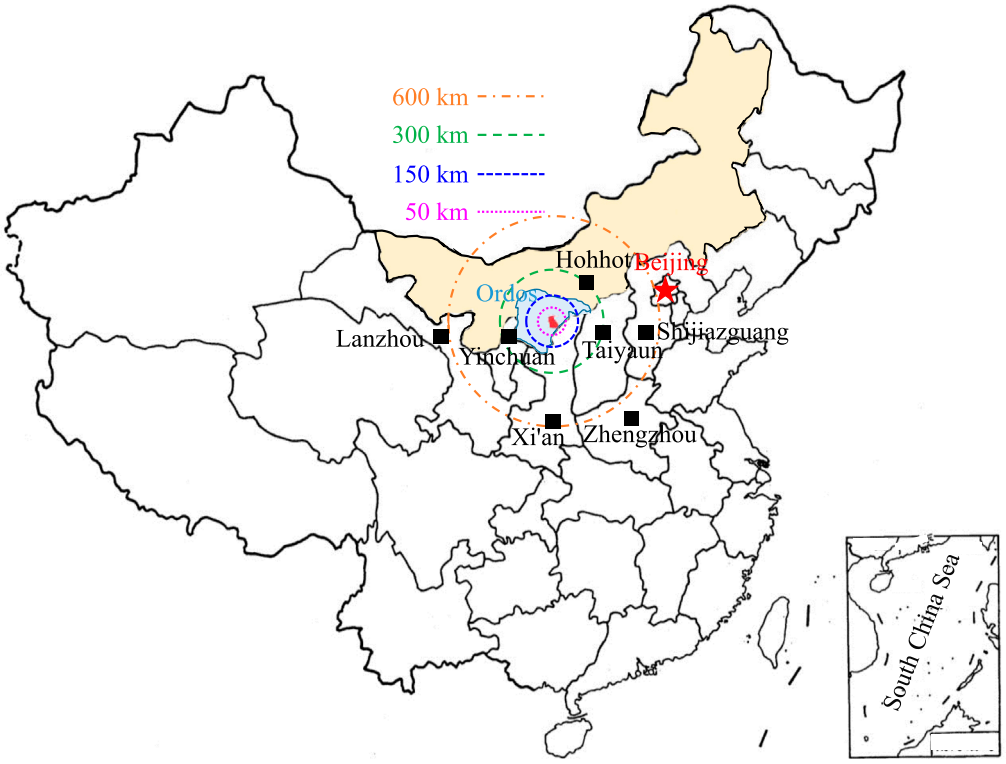

FIGURE 2
Geographical location map of the XTMA

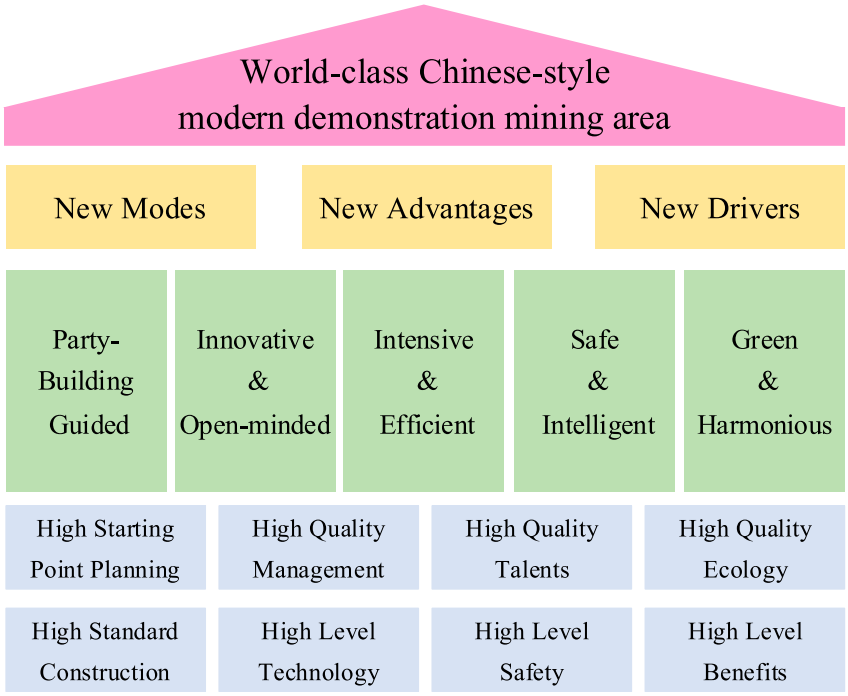

FIGURE 3
XTMA "1358" development strategy diagram.

harmony and happiness. We will promote the deep integration and coordinated development of mining areas with new energy, new technologies, and new industries, thereby enhancing the competitiveness of corporate responsibility. We strive to create the maximum economic, environmental, and social value for stakeholders.

Based on the above requirements and objectives, XTMA can ultimately achieve comprehensive, coordinated and sustainable development. Therefore, the high-quality development of XTMA features a full life cycle, comprehensive elements, overall harmony, ecological priority, technological leadership, and market demand orientation.

3 Overall development concept of XTMA high quality development

From the perspective of the entire life cycle of mining areas, we carry out the national five development concepts, implement the new energy security strategy of "four revolutions, one cooperation," and the overall development strategy of the China Energy Investment Corporation's "one goal, three types and five modernizations, seven first-class" enterprises. Based on the external development environment and internal development conditions of the enterprise, as well as the actual situation of the mining area, the overall development strategy of the mining area has been planned, which can be summarized as the "1358" development strategy, as shown in Figure 3.

"1358" development strategy is elaborated as follows.

"1" represents the ultimate goal of high-quality planning in this mining area, which is to build a world-class demonstration mining area with Chinese modernization. This is the mission layer of our strategic development thinking. At the same time, this goal is also the implementation of the "1357" strategic target of the China Energy Investment Corporation.

"3" represents new models (integrated coal fields, one development company, one-time planning, step-by-step implementation), new advantages (resource advantage, location advantage, latecomer advantage, local enterprise advantage), and new driving forces (leading technology, leading talents, refined management, coordinated development). By gathering new driving forces to create new models and better leverage new advantages, this is the power layer of our planning thinking. This is also a profound implementation of the spirit of the 20th National Congress of the Communist Party of China, that is, to explore new areas and new tracks for development, and continuously create new momentum and new advantages for growth.

"5" represents the specific target attributes that the mining area will achieve in the future, including a party-building guided mining area, an innovative & open mining area, an intensive & efficient mining area, a safe & intelligent mining area, and a green & harmonious mining area. In other words, under the absolute leadership of the Chinese Communist Party, the "Five Types" construction of XTMA corresponds to the "Five Transformations" development of the group company, directly depicting and promoting the long-term blueprint of XTMA and advancing its high-quality construction.

"8" represents the assessment indicators for whether the predetermined goals have been achieved in the planning and construction process of the mining area. They are high starting point planning, high quality management, high quality talents, high quality ecology, high standard construction, high level technology, high level safety, and high level benefits. At the same time, "8 High" is also the

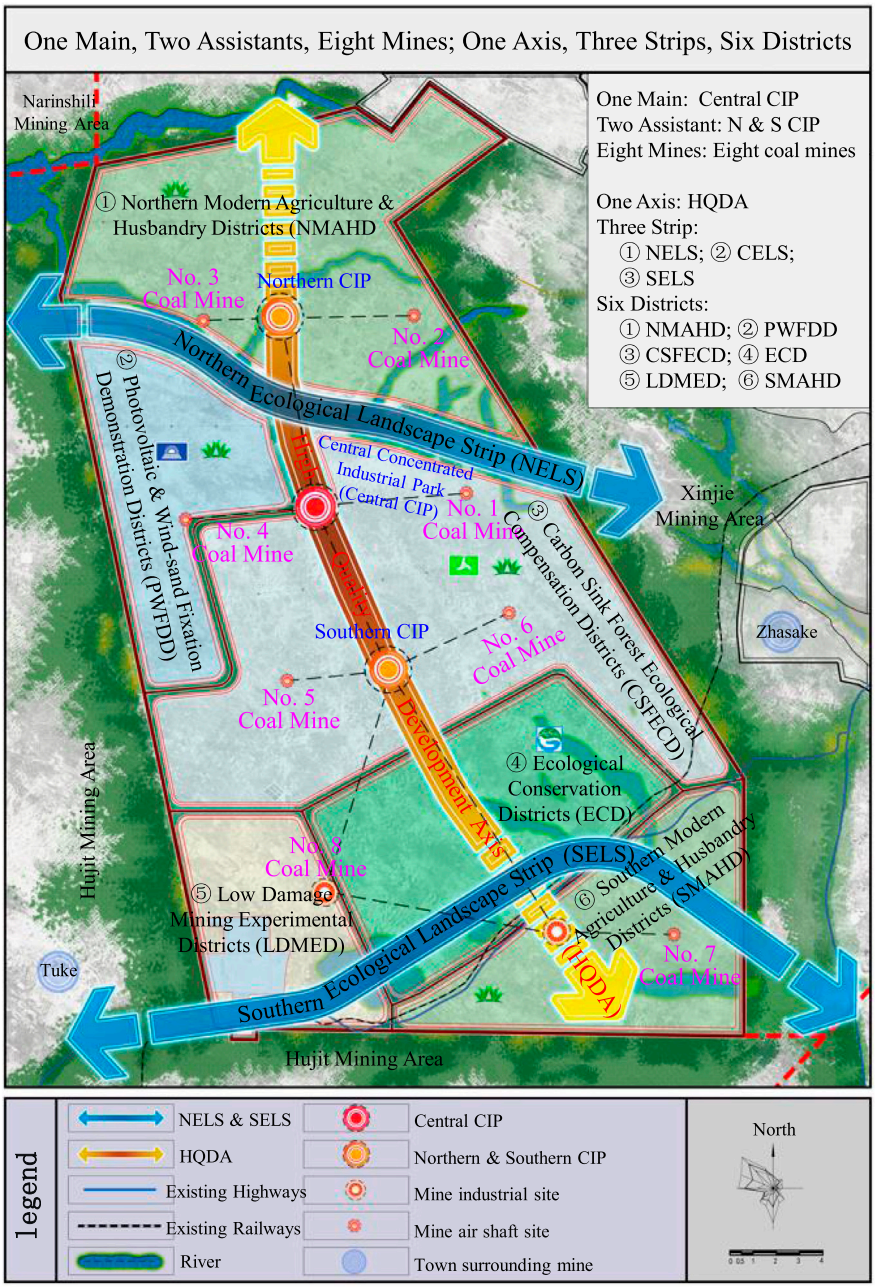

FIGURE 4
Spatial structure planning diagram of the XTMA.

guarantee for the high-quality development of the mining area, and it is a highly condensed execution layer of this plan.

4 Implementation path of XTMA high quality development

4.1 Reasonable development layout planning

Space planning should coordinate the three major spaces of production, living, and ecology, following the planning principle of "favorable production and convenient living." We should coordinate the new energy industry, build a green development layout, develop modern agriculture and husbandry, promote a community of interests between industry and agriculture, and build an innovative model of mining area development that integrates regional development. As a result, a cluster style industrial park with livable and suitable industries, beautiful environment, and complete functions will be formed (Wang, 2019b; Niu, 2019). The spatial development layout of the intensive and efficient cluster demonstration area for planning the integration of cluster mining is shown in Figure 4.

Taking into account the positioning, development goals, and current conditions of the mining area, we adhere to coordinating

local government planning and enterprise development to build a high-quality mining area that is livable and suitable for balanced development. Therefore, we have planned and formed a spatial development layout of the mining area with "One main, Two Assistant, Eight Mines; One Axis, Three Strip, Six Districts."

"One main, Two Assistant, Eight Mines" is a concise summary of the spatial structure layout of core production ground facilities in mining areas such as planned mines and coal preparation plants.

"One main", i.e., Central Concentrated Industrial Park in the XTMA (Central CIP), includes the joint industrial site of No. 1–No. 4 Coal Mine, installation stations, main auxiliary facilities (water supply, power supply, communication, heating), affiliated enterprises, roads, etc. "Two Assistant", i.e., Concentrated industrial parks in the north and south of the XTMA (N & S CIP) , includes the industrial sites of No. 2–No. 3 Coal Mine (located in the North CIP) and No. 5–No. 6 Coal Mine (located in the South CIP), some auxiliary facilities (water supply, power supply, communication, heating), affiliated enterprises, installation stations, roads, etc. "Eight Mines", i.e., eight large coal mines (No. 1–No. 8 Coal Mine) planned in the mining area, with a planned production capacity of 56.0 Mt/a.

"One Axis, Three Strip, Six Districts" is a unified planning and summary of the development axis of mining area planning, green electricity, photovoltaic wind energy, ecological agriculture and husbandry, and other related industries.

"One Axis" is a high-quality development axis that runs through the central part of the mining area from north to south. "Three Strip" are the Northern Ecological Landscape Strip (NELS), the Central Ecological Landscape Strip (CELS), and the Southern Ecological Landscape Strip (SELS). "Six Districts" are the Northern Modern Agriculture & Husbandry Districts (NMAHD), the Photovoltaic & Wind-sand Fixation Demonstration Districts (PWFDD), the Carbon Sink Forest Ecological Compensation Districts (CSFECD), the Ecological Conservation Districts (ECD), the Low damage mining experimental Districts (LDMED), and the Southern Modern Agriculture & Husbandry Districts (SMAHD).

4.2 Construction of intelligent and safe mining area

We will deploy an integrated management and control platform in accordance with the "Six Unifications, Large Concentration" construction model of the group company. Plan to build a three-dimensional transparent geological guarantee system with high standards and actively apply digital twin technology. In this planning path, it is planned to comprehensively build an intelligent network system of coal industry with intelligent perception, intelligent decision-making and automatic execution. Continuously promote the deep integration of advanced information technologies such as 5G, big data, cloud computing, and artificial intelligence into coal mining production scenarios. Based on this, we will achieve remote control and intelligent management of production systems in coal mines and coal preparation plants, assisting in the development of "reducing personnel, increasing safety, and improving efficiency" in mining areas (Wang et al., 2019a; Wang et al., 2020a; Hou et al., 2022; Kang et al., 2023). The planning ideas and goals for intelligent and safe mining areas are shown in Figure 5.

Following the phased implementation and step-by-step improvement approach, the timing planning for intelligent and safe mining areas is as follows.

Short-term goal (2023–2026): In the plan, it is planned to build a "One Cloud Computing" of intelligent mining for Xinjie Energy, and to build a high-speed transmission network and network management for the mining area. We plan to build a company data center, a spatiotemporal intelligent GIS multi-dimensional geographic information platform, an intelligent integrated control platform, and a mining area intelligent decision-making center to achieve intelligent mining.

Mid-term goal (2027–2033): The intelligent construction, backbone transmission network and other information infrastructure of the company and mining area, the intelligent integrated control platform of the mining area, and the spatiotemporal intelligent GIS multi-dimensional geographic information platform are expanded and improved according to the mine construction sequence. Based on this, XTMA is gradually achieving intelligence across the entire mining area.

Long-term goal (2034-): The XTMA will complete the construction of a smart and safe mining area based on the overall architecture of "One Cloud Computing, Multiple Edge Computing, One Backbone Network, Multiple Professional Networks, Three Platforms (Intelligent Integrated Control Platform of Xinjie Energy, Intelligent Coal Mine Comprehensive Control Application Platform, and Intelligent coal selection comprehensive control application platform), Five Centers (safety decision-making, production decision-making, business decision-making, smart people's livelihood, and smart ecology), and N Intelligent Application Scenarios." Through the above planning, the establishment of a digital asset system for Xinjie Energy can achieve digital empowerment and achieve advanced intelligent mining area construction of "intelligence, personnel reduction, efficiency improvement, and increased safety."

4.3 Construction of integrated zero carbon mining area

This path plan will benchmark the dual carbon target to build a diversified clean energy supply system. The long-term expectation is to form a zero carbon demonstration zone that covers zero carbon management, zero carbon supporting facilities, zero carbon mining life, and diversified collaborative development (wind, solar, electricity, and heating). The ultimate goal of the planning is to achieve "positive and negative offset zero emissions" in the mining area (Liu et al., 2019b; Lin, 2022), as shown in Figure 6. There are three stages in the construction timeline.

Phase 1 (2023–2032): Energy conservation and emission reduction, reaching peak as soon as possible.

The 8 coal mines in the mining area are planned to be completed and put into operation by the end of 2032, with a production capacity of 56Mt/a. The node of the first phase construction of a zero

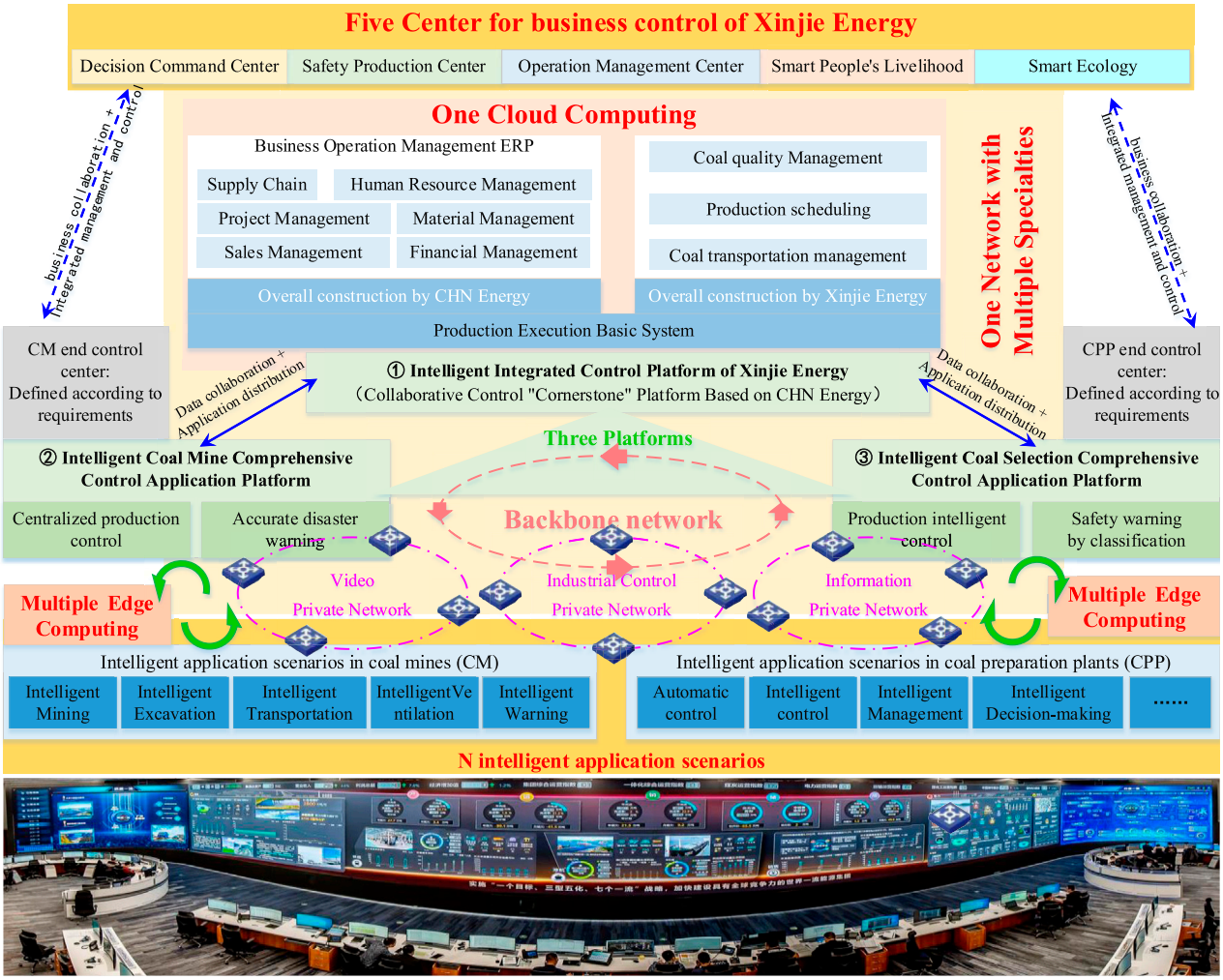

FIGURE 5
Overall planning blueprint for the construction of the intelligent and safe mining area.

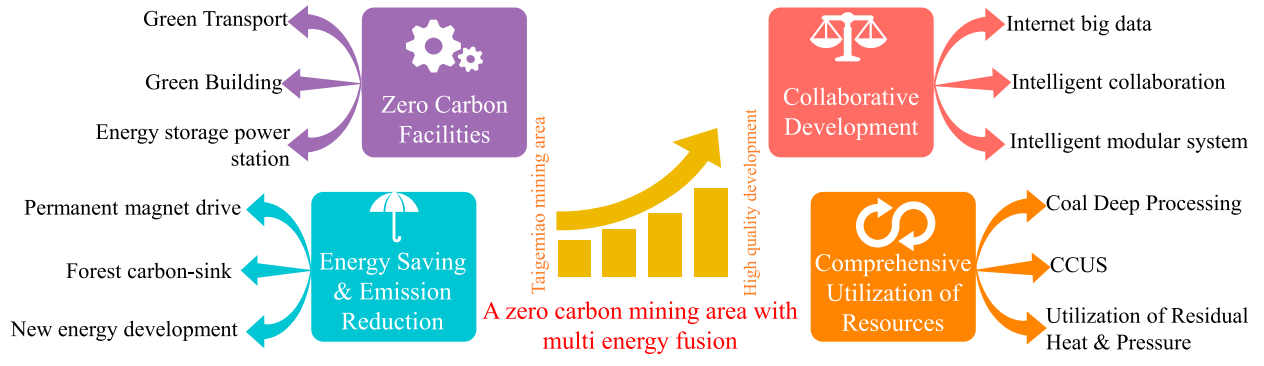

FIGURE 6
Implementation path diagram of zero-carbon mining area.

carbon mining area is the official production of all coal mines in the mining area. During this period, the mining area plans to build zero carbon building infrastructure (electrification, photovoltaic, and recycling of building construction and operation; installation of photovoltaic equipment on building surfaces; and the use of new energy vehicles to form a “decarbonization” transportation energy

system). These technologies and solutions will enable the mining area to achieve carbon peak once all coal mines are fully put into operation.

The recent quantifiable planning goals are as follows: invest in electric vehicles and 30 hydrogen-powered vehicles; construct 2 integrated hydrogen refueling and battery charging/exchanging stations; build a 100,000 kW/400,000 kWh energy storage station; achieve a 44% forest land coverage and 40% grassland coverage in the mining area; construct 42.4 km^2 (2.07 million kW) of photovoltaic and 83 km^2 (200,000 kW) of wind power facilities.

Phase 2 (2032–2035): Deep decarbonization and low-carbon transformation.

After continuous construction, XTMA has basically built a first-class high-quality mining area by 2035. At this stage, the established functions of the mining area are equipped, the technology is advanced, and the conditions are mature. The construction of new energy infrastructure such as solar energy, wind energy, and energy storage in the mining area is complete. Therefore, we plan to integrate and coordinate the energy demand and supply of the mining area. By combining new energy substitution projects with green facilities and green buildings to achieve decarbonization, we will further achieve the transformation and progress from low-carbon mining areas to zero carbon mining areas.

Phase 3 (2035-): Comprehensive neutralization and zero carbon mining area.

Looking ahead to the year 2035, all planned mines in the mining area have been completed and put into operation, and are expected to perform well. Through natural carbon sink, CCUS, comprehensive utilization of residual pressure and waste heat and other technologies, low-carbon mining areas have been successfully transformed and upgraded to zero carbon mining areas, realizing comprehensive carbon neutrality of the mining area and be-coming world-class benchmark mining areas.

4.4 Construction of ecological green mining area

The planning of this section follows the principles of overall layout, zero carbon efficiency, people-oriented, and ecological priority. We plan for the entire life cycle of the mining area, including preparation for construction, production after completion, and future transformation. The planning content is divided into six parts, including environmental requirements for mining areas, resource development methods, ecological protection and restoration, comprehensive utilization of resources, and green innovation drive, covering all aspects of green development in mining areas, as shown in Figure 7. The planning approach ensures a green development model for mining areas based on coal, centered on high-quality development, taking diversified and efficient development as measures, constrained by ecological environment protection, driven by resource recycling, and guaranteed by green innovation (Jin et al., 2020; Wang et al., 2020b; Liu et al., 2022).

We adhere to the "three simultaneities" of mining, protection, and governance, with a people-oriented approach of first relocating, then mining. During the production period of the mining area, it is necessary to standardize the treatment and resource utilization of industrial waste, and pay attention to achieving full cycle protection of the environmental ecology. During the construction period of the mining area, it is necessary to meet the requirements of green mining construction, such as greening and beautification of the mining area, as well as the standardization and efficiency of building layout. The construction of green mines also needs to ensure the scientific and reliable production layout and process technology, and plan and implement low-loss mining in advance (such as water conservation, filling sedimentation reduction, gas coal coordination, etc.). During the development period of the mining area, new energy sources such as photovoltaic, wind power, geothermal, and biomass energy should be reasonably developed. It is necessary to strengthen the monitoring and protection of regional ecological environment in mining area development, such as geological disaster prevention and control, aquifer damage repair, air pollution, mining subsidence, etc. We plan to utilize advanced technology and equipment for efficient resource recovery (intelligent high mining face, underground coal liquefaction, etc.), clean coal utilization (coal washing, coal to oil, coal to gas, etc.), and co associated resource utilization (mine water, coal slurry, waste heat, etc.). In addition, it is necessary to implement measures for energy conservation, emission reduction, and clean energy substitution (green electricity, hydrogen energy), develop a circular economy, and integrate green technological innovation and green development culture throughout the development of mining areas.

4.5 Construction of technological innovation highlands

The planning of this section is guided by the actual needs of the mining area, with the aim of promoting the agglomeration of innovative resources and improving the scientific and technological innovation system (Liu et al., 2021). Based on the major key technological needs and social responsibilities of different periods, the construction of technological highlands is divided into three stages (construction period, pioneering period, and integration period). In addition, we plan to build a collaborative innovation three-level technology research and development platform, hoping to solve the key problems that restrict the high-quality development of mining areas through this platform's technology research and development. At the same time, this platform can further break through the common key technical challenges that constrain the development of the coal industry. The construction concept of technological innovation highlands is shown in Figure 8.

During the construction period, in response to the complex mining technology conditions in the mining area, we will focus on conducting basic research on disaster prevention and control and well construction technology research from four dimensions: safety, ecology, efficiency, and benefits. The key technologies during the construction period mainly focus on the mining technology of rock burst mines, the protection and utilization technology of mine water resources, the protection and comprehensive management technology of the ecological environment above and below the

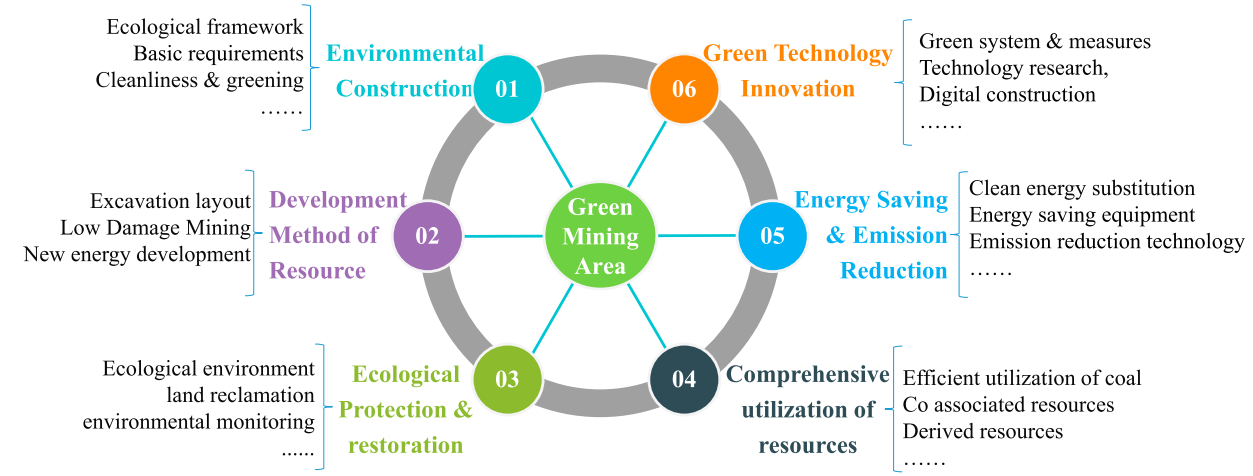

FIGURE 7
Implementation path diagram of green mining area.

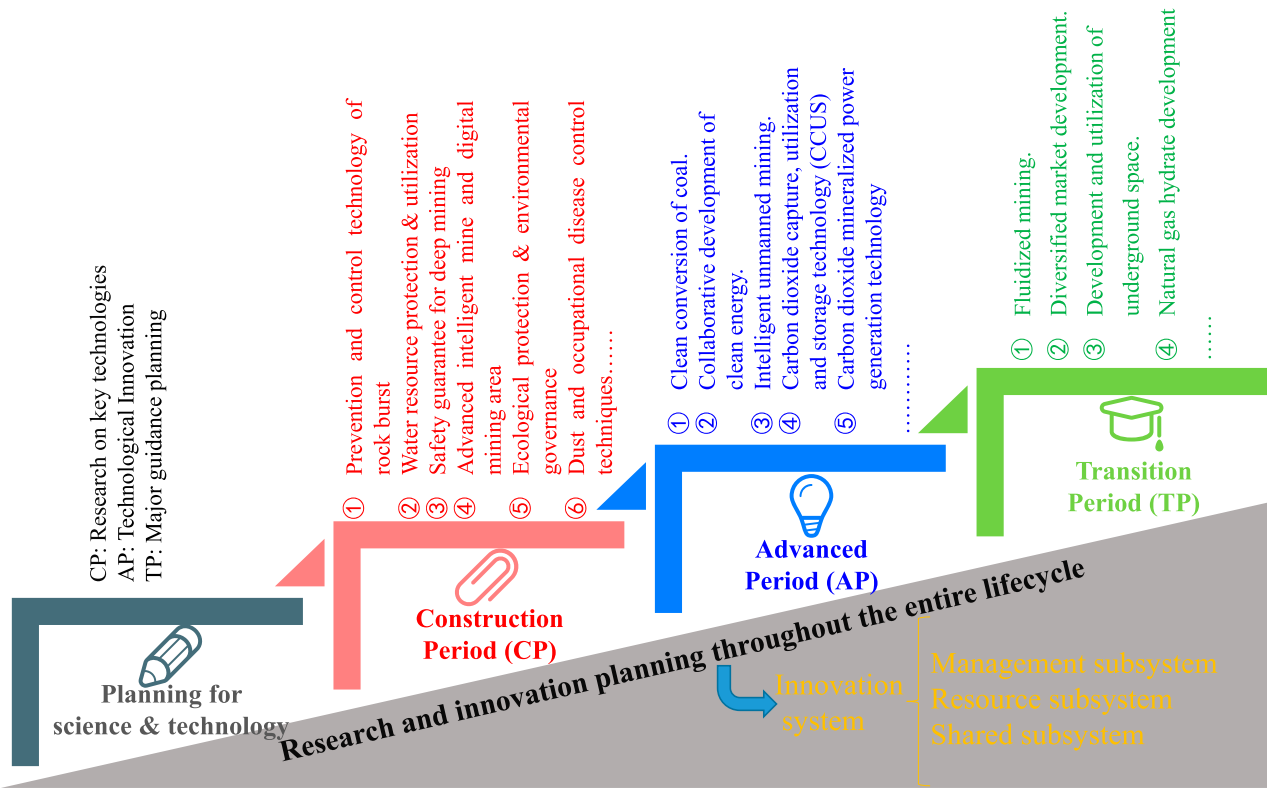

FIGURE 8
Concept of science and technology innovation.

mine, the strategic planning of coordinated mining of coal and natural gas resources, the safety and digital construction technology of mines, and so on (Fan et al., 2021; Jiang et al., 2023; Li et al., 2023; Lyu et al., 2023; Xiong et al., 2023).

The pioneering period mainly focuses on the key technical research directions during the construction and retirement stages of high-quality mining areas, as well as the important technical guidance to lead the development of the coal industry from an industrial perspective. Key technologies to focus on include unmanned mining, fluidized mining, comprehensive development and utilization of underground space, integrated development and utilization of resources, UCG, CCUS, etc.

The construction system of the collaborative innovation three-level technology research and development platform includes a technology management subsystem, a technology resource subsystem, and a research sharing subsystem. The three-level platforms are composed of a basic practice base rooted in coal mines (First level R&D platform: exploring engineering experience, implementing innovative technologies, and implementing safety production), a technology innovation platform based on mining areas (Second level R&D platform: Intensify the common challenges and development needs of various mines, and establish a technology innovation R&D center to serve this mining area), and a collaborative innovation community serving the industry (Third level R&D platform: based on the XTMA and relying on CHN Energy Corporation, solving key scientific problems in mining development, serving CHN Energy Corporation and leading the industry). The establishment of this platform will greatly promote the implementation of industry, academia, research and application.

4.6 Construction of cluster management mode

Combining the positioning and specificity of XTMA, we have constructed a "cluster management" paradigm (The XTMA plans to build eight large coal mines, the unified management of eight coal mines constitutes a cluster management mode) and formed a new "1337" mining area development and management model. "1" is a strategic policy, which is to promote XTMA's strategic vision of building a world-class high-quality demonstration mining area. "3" refers to three goals and three driving forces, respectively. The meaning of the three goals is that the management during the high-quality development of mining areas should always revolve around the three goals of safety, efficiency, and green. The three driving forces mean that technological innovation, management innovation and cultural innovation promote the realization of goals. "7" represents the seven paths to implement this management mode, namely, flattening, specialization, marketization, refinement, standardization, intellectualization, and cleanliness. Under the guidance of the "1337" new mining area development and management model, the mining area cluster management model has formed an orderly, stable, hierarchical, and diversified system connotation.

Establish a framework for the "cluster mining" management innovation system based on the innovation of cluster management mode, as shown in Figure 9. The system framework specifically includes 10 aspects, including Coal Mine Safety Risk Pre Control Management System, Benchmarking Management System, Comprehensive Cost Refinement Management System, Integration System of Industry & Finance, Enterprise Standard System, Professional Management System, Flat Organizational Structure Management System, Green & Low-Carbon Management System, Internal Market-Oriented Management System, and Human Resource Management System. The system framework clarifies management objectives, approaches, and main methods and modes. The application of this management system can enhance the scientific management level of enterprises. In addition, the management system also clarifies the future development direction and will provide strong support for building world-class high-quality demonstration mining areas.

4.7 Construction of harmonious and eudemonic mining area

Xijinping pointed out that "only enterprises that actively undertake social responsibility are the most competitive and viable enterprises." The construction of XTMA should be based on the "RISE" brand strategy of CHN Energy Corporation, and deeply integrate the concept of "Heaven-Earth-Human" responsibility culture. In the process of high-quality development of XTMA, enterprises must take up social responsibility, do their own work and positioning well, and achieve coordination and balance in the following four aspects:

(1) Coordination and balance between mining areas and industrial structure: the development of mining areas must be coordinated and balanced with the local industrial structure, to ensure that its development will not have a negative impact on other industries in the local area, but will promote sustainable economic development in the local area. For example, the formation of coal-based coal development, coal washing, coal chemical industry, coal power plant, professional team, life service supply and other industries.
(2) Coordination and balance between mining areas and natural environment: the development of mining areas needs to consider the impact on the local natural environment, protect the ecological environment, protect biodiversity, and achieve sustainable development. For example, the green area in the mining area has been further improved, environmental pollution has been controlled, and the village appearance has been improved.
(3) Coordination and balance between mining areas and urban and rural areas: the development of XTMA needs to consider the coordination and balance with local urban and rural areas, promote the economic development of the local society and improve the living standards of the people. For example, people in and around mining areas have more diverse types of work and higher incomes.
(4) Coordination and balance between mining areas and employee happiness: the development of the enterprise must be coordinated and balanced with the realization of employee happiness, guarantee the rights and welfare of employees, improve their job satisfaction and happiness, and promote harmonious labor relations. The contents closely related to people's lives in the working environment, housing, education, medical care, and elderly care have been improved, and the economic material has been greatly satisfied.

To achieve a humanistic and harmonious eudemonic mining area, we need to start from three aspects. Firstly, enterprises must establish a concept of social responsibility work, which not only creates better economic benefits internally but also fulfills its own social responsibility externally. Secondly, it is necessary to establish a mechanism of cooperation and development between mining areas and local enterprises. In the process of mining area development, enterprises should participate in local construction in multiple dimensions and give full play to their social responsibility. Finally, it is necessary to focus on the happy life of employees. While creating a safe and low-intensity work environment, provide

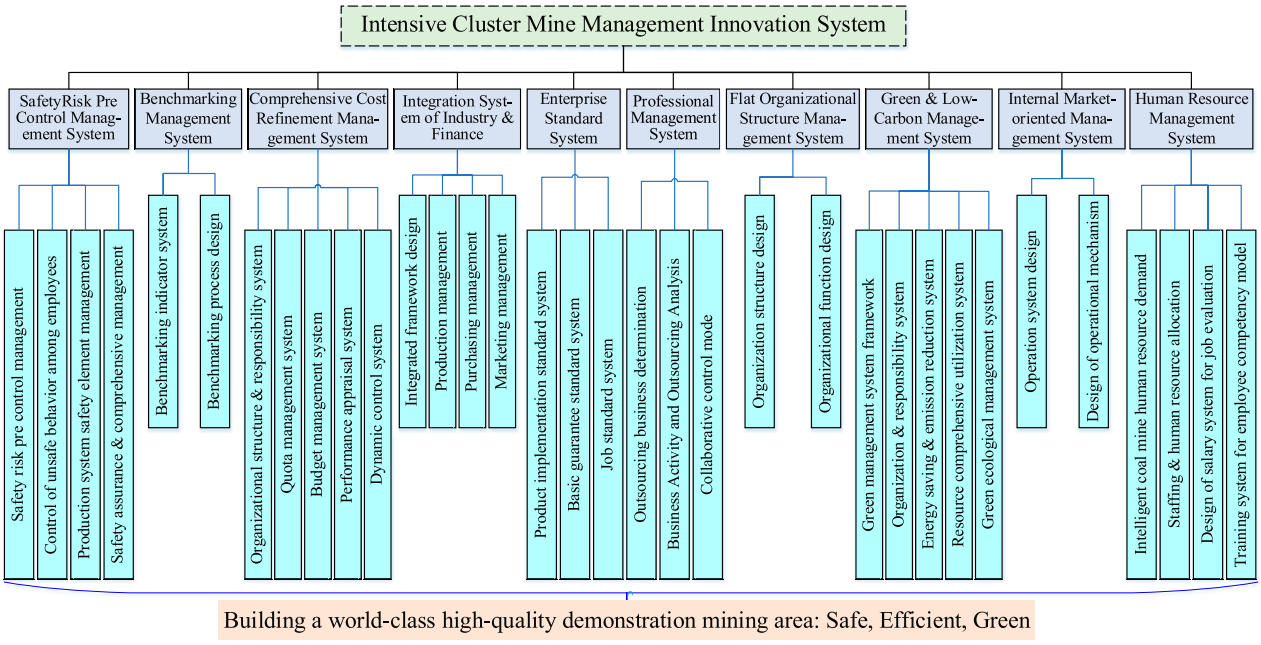

FIGURE 9
"Cluster mine" management innovation system framework.

better salary and comprehensive welfare protection for employees, constantly improve their sense of acquisition, happiness and security, thus achieving a humanistic and harmonious eudemonic mining area.

5 Objectives and significance of mining area phase construction

5.1 Stage goals for high-quality development of mining areas

① Short-term goal (2023–2030): Preliminary first-class

The period from 2023 to 2030 is our short-term goal, and we aim to achieve a preliminary first-class level. Specifically, we plan to complete the construction and operation of the four wells in the northern part, reaching a scale of 28.0Mt/a, and improve the functions of the mining area. We also plan to establish an intensive and efficient industrial park that integrates innovation, intelligence, safety, efficiency, greenness, and happiness, providing a better environment and conditions for our production. In addition, we will strive to create a beautiful and livable happy mining area and provide better living conditions and welfare guarantees for our employees.

② Mid-term goal (2030–2035): Basically first-class

The period from 2030 to 2035 is the achievement of the mid-term goal construction, during which all eight coal mines in the mining area will be in full operation, with a total production capacity of 56.0 Mt/a. Specifically, we have built an intensive and efficient mining cluster demonstration zone, innovation-driven smart safety leading zone, multi-energy integration zero-carbon advanced zone, and beautiful and eudemonic green model zone. The basic completion of these different modules in the mining area has also promoted the basic construction of a world-class high-quality development demonstration mining area.

③ Long-term goal (2035-): Comprehensively first-class

During this period, we will consider relocating water sources and developing the northern exploration area; we are committed to building the mining area into a national coal reserve base with a capacity of billions of tons. At the same time, we will also build and put into good use the green electricity industry, agriculture and husbandry, carbon sequestration forest ecological compensation area, and low-loss mining experimental area. This will allow relevant parties to fully benefit from the dividends of high-quality development. Ultimately, we will fully build a world-class high-quality development demonstration mining area.

5.2 The significance of XTMA's high-quality development

XTMA is a national coal strategic reserve base. In the context of the world undergoing unprecedented changes, China is shifting its economy towards high-quality development (Liu et al., 2019a; Kang et al., 2023), deepening its new energy security strategy (Li et al., 2022; Li et al., 2023), pursuing the dual-carbon goals (Xie et al., 2021b; Miao et al., 2022), protecting the ecological environment of the Yellow River Basin (Wang, 2019b; Yu and Zhang, 2022), and facing the growing global energy crisis (Hao, 2022). Against this

FIGURE 10
The central industrial Park of the XTMA.

backdrop, the high-quality development of XTMA is particularly critical and urgent.

Building XTMA into a green, safe, efficient and intelligent international first-class modern benchmark mining area can not only fully leverage the role of CHN Energy Corporation as a "national team" and "main force" in energy supply, but also effectively embody its function as a "voltage regulator" and "ballast" in energy supply. It can also guide the scientific development of the mining area in the next 30–50 years and form a replicable and promotable experience. In addition, the high-quality development of XTMA will play a leading role, which is of great significance for the high-quality development and transformation of the coal industry, supporting the development of CHN Energy Corporation and local economic growth, and is also a necessary condition for building a world-class modern benchmark mining area. The surface planning of the central industrial park in the XTMA (serving No. 1 Coal Mine to No. 4 Coal Mine) is shown in Figure 10.

6 Summary and suggestions

6.1 Summary

China's resource endowment determines that coal development plays a fundamental role in ensuring energy security, and mining area development is the most basic and important link in the coal industry. The high-quality development of mining areas is the cornerstone of the continuous implementation of high-quality development of the coal industry in the new era.

Based on the research of high-quality development planning in this article, XTMA can be developed into a "smart and safe leading area, cluster management demonstration area, zero-carbon advanced area, and green model area." Our vision is to ultimately achieve the "Five-Zero Goals" in XTMA, which are: zero fatalities in safety, zero injuries in health, zero damage in mining, zero emissions in environmental protection, and carbon neutrality in carbon reduction (zero carbon). The high-quality development of XTMA will promote the open sharing of new concepts, new strategies, new technologies, and new models in the coal industry, and then form the "Xinjie model" that leads the development of the coal industry in a new paradigm. At the same time, the high-quality development of XTMA will also promote the upgrading of this mining area into a carrier of upgrading the Chinese coal industry and a world-class modern benchmark mining area, leading the high-quality development of the coal industry.

6.2 Prospect

The high-quality development of XTMA will exert a strong driving force on the high-quality development of China's coal industry, and the coal industry will undergo changes in coal production, supply, utilization, and other aspects in the future.

For example, coal production will achieve highly intelligent automation, realizing the vision of "drilling without going down the well, mining without seeing the coal" and "underground robots, surface technology personnel." Another example is that coal supply will form a model of "flexible production and customized

marketing." Moreover, coal utilization will achieve a trend of "clean, low-carbon, high-end, and diversified."

6.3 Suggestions

To strengthen the implementation path of this plan, we have put forward the following five suggestions for Xinjie Energy.

① Designating XTMA as a leading area for high-quality development of coal industry.
② Establishing a national-level energy technology R&D and technology collaborative innovation center.
③ Developing ecological construction standards for mining areas and scientifically delineating ecological conservation redlines.
④ Exploring safety supervision models that are compatible with efficient management models.
⑤ Give full play to the role of local government in overall planning and coordination.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

DX: Conceptualization, Funding acquisition, Project administration, Resources, Writing–review and editing. CL: Conceptualization, Visualization, Writing–original draft. TC: Data curation, Formal analysis, Writing–original draft. XF: Resources, Writing–review and editing. QZ: Investigation, Writing–original draft. HC: Investigation, Writing–original draft.

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Conflict of interest

Authors DX, CL, TC, QZ, and HC were employed by CCTEG Wuhan Engineering Company.

The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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