



5G Smart Mining Project of Lvliang Xinyan Coal Mine



Since its launch in early November 2020, the 5G ring network in Xinyan Coal Mine has been running stably to support all-weather remote coal mining in the underground intelligent working face. The laborious and dangerous underground work has been replaced with labour-saving panel operations in the office. In 2021, we further expanded the application of 5G in the principle of cost-effectiveness and practicability, and implemented 5G support for 27 subsystems, enabling highly efficient transmission and application of mine big data. In 2022, we expect to make possible 5G-enabled personnel positioning and scaled application of 5G slicing, and enhance the construction of 5G + intelligence to achieve comprehensive cognition and intelligent control across the mine area, building Xinyan into a new benchmark for 5G + smart mining in China.

Deng ChengJun

Chairman of Lvliang Xinyan Coal Mine

Partners



Case Overview

Xinyan Coal Mine, a coal mining company under Lvliang Dongyi Group Coal Gasification Co., Ltd., has a recoverable reserve of 160.99 million tons and an approved production capacity of 2.4 million tons a year. Since the emergence of 5G technology, Xinyan Coal Mine has actively embraced the construction of 5G + smart mining in response to the national call, in the hope of realising intelligent safety monitoring, production and management featuring increased safety and efficiency as well as less manpower via 5G + intelligence, thereby improving the profitability of the digitalized company. Among the first batch of mines with full underground 5G coverage in China, Xinyan Mine Coal was selected as a national example of intelligent mines in 2020.

In June 2021, Xinyan Coal Mine started the project of converging its nine subsystems with 5G network based on the 5G network and application project at the first phase. In November 2021, the convergence project was completed for acceptance inspection. During the construction and launch of the project, Xinyan Coal Mine joined hands with its partners in the ecosystem including China Mobile Shanxi, Huawei, and Sany Electronic to promote 5G network optimization and incubation of planning-deployment-optimization services suitable for the mining industry. From here, 5G + smart mining has moved on a trajectory from "available" to "productive".



Industry Challenges

Operational safety to be improved

Safe production is the top priority of coal companies. Despite the fact that the death rate per million tons of coal mined fell from 0.093 in 2018 to 0.083 (316 deaths in 170 fatal accidents) in 2019, this figure was still 5 times that of the United States and 11 times that of Australia, at the level of a moderately developed coal-producing country. There was an urgent need to improve working conditions and reduce manpower in underground production by means of mobile communication technologies to minimize production safety accidents.



5G+ Smart Mining

Recruitment difficulty and labour shortage

The average workforce age in the coal industry is above 45 years. Due to factors such as many hazards and risks, poor working environment, intense workload, and long working hours, it has been increasingly difficult to recruit younger workforce, which might lead to a critical labour shortage in the next 5 to 10 years. As the coal industry remains a pillar energy industry in China, it was imperative to address the workforce issues by leveraging intelligent approaches and mobile communication technologies.

Hurdles in centralised management

The coal mining, tunnelling, electromechanical, conveying, and ventilation systems are distributed in underground tunnels that span over dozens of kilometres. Many areas down the mine are accessible only on foot due to hurdles in underground transport, conveying, and scheduling. Reading meters on site was the only way to monitor production and safety data on people, machines, and the environment, which was inefficient and not on a real-time basis. It was a challenge to solve the centralised management of distributed production systems to reduce workload and improve efficiency.

Multiple isolated networks

Different networks were deployed in underground systems for different purposes such as production, communication, and management. With the capacity to address business requirements with one common network, 5G provides solutions to centralised operation serving the purpose of multiple networks.



Solutions and Benefits

In view of the big difference in network requirements amongst systems used in the coal industry, as well as the extremely high demands on safety, availability, and stability of networks and systems, the project team tackled the challenges from the application, network and service dimensions:

Promoting the convergence of intelligent applications with 5G to realise smart mining:

Targeting industry pain points, the project team worked with China Mobile Shanxi, Huawei, and OT ecosystem partners to introduce eight intelligent subsystems that address practical issues in the actual production of mines.

Advancing the implementation of key network features to accelerate network adaptation to the industry:

The project team released the first high-availability MEC kite-like solution jointly with China Mobile Shanxi and Huawei, and implemented 5G and ring network active-standby capability of subsystems in specific scenarios with China Mobile Shanxi, Huawei, Sany and OT ecosystem partners.

Incubating the integrated service of planning, deployment and optimization that serves as a bridge for integration of business and network:

Through joint efforts with China Mobile Shanxi and Huawei, the project team incubated the integrated service of planning, deployment, and optimization based on the launch of eight intelligent subsystems, and aligned business requirements with network features through technical means. With clear business requirements for network planning, the team ensured the availability and stability of the final delivered network, so that the network and applications may better serve the industry, solve business difficulties, and create practical value.

Based on unified 5G network, 5G applications in eight areas as follows were explored under the 5G Smart Mining Project of Lvliang Xinyan Coal Mine:

01 Main inclined shaft hoist monitoring system

The main inclined shaft transports materials mainly using a winch with a lifting and lowering capacity of up to 50 tons. This system, which is powered by 5G technology, allows for operational control of the hoist as well as monitoring of component and system condition and running information.

Benefits Unattended operation, with 8 onsite winchmen reduced.



02 Power monitoring system

The substation, as an underground power supply system, consists of high-voltage switches, low-voltage switches, and mobile substations. This system reads and controls high-voltage and low-voltage switch status in real time and monitors the conditions inside the underground substation via surveillance videos.

Benefits Unattended operation, with 8 onsite on-duty workers reduced.



03 Auxiliary shaft winch remote monitoring system

The auxiliary vertical shaft lifts objects and people via cages with a maximum lifting capacity of 7.5 tons. This system allows automatic start and stop of the winch to lift and lower the cages to designated positions and monitors winch operation in real time.

Benefits Unattended operation, with 5 onsite winchmen reduced.



04 Endless rope winch unattended system

The endless rope winch pulls mine cars, flat cars, and other transport facilities using an endless wire rope to transport materials and large equipment over a long distance. This system remotely controls and locates the winch and monitors the operational conditions of the winch via surveillance videos.

Benefits Unattended operation, with 12 onsite winchmen reduced.





05 Monkey car remote monitoring system

The monkey car operates in a circulating and endless way with the driving wheels and wire rope to transport miners on chairlifts over a long distance. This system remotely starts and stops the monkey car, gives alarms, and monitors the operational status in real time.

Benefits Unattended operation, with 2 onsite on-duty workers reduced.



06 Pump house drainage system

Xinyan Coal Mine has a main drainage automation system with three pumps, of which two pumps are active and one is on standby. Based on Siemens S7-300PLC and iFIX configuration software, an underground drainage centralised control system was built which automatically starts the pumps to drain the water when the set high water level is achieved and stops the pumps when the set low water level is reached. This system also allows remote centralised control, such as one-click start and stop, and gives voice alarms with automatic switchover in case of pump failures. Coupled with the above capabilities, the real-time data display on the upper computer enabled by the iFIX configuration software makes unattended drainage possible.

Benefits Unattended operation, with 2 onsite on-duty workers reduced.



07 Wire rope flaw detection system

With the help of the flaw detector and speed sensor, the system detects the severity and location of damage to the wire rope and belt during their operation, and reports these data acquired with 5G data collection capability to the monitor console of the centralised control centre so that the maintenance staff can take actions accordingly.

Benefits This system significantly reduced the wire rope and belt inspection workload and identified problems timely.



08 Unmanned electric locomotive

Rail electric locomotives are mainly used to transport materials aboveground and underground. The unmanned locomotive system transmits back data about the locomotive's surroundings and operational conditions via 5G network, allowing the operator to remotely control the locomotive, such as starting/stopping, accelerating/decelerating, tooting, and turning on lights. The system supports autonomous driving, remote driving, and mobile-end controlled driving.

Benefits One onsite electric locomotive driver was reduced per set.



Economic benefits

From the perspective of coal companies, 5G network and intelligent application subsystems helped them reduce human resource. With the 5G network in place, mining efficiency was improved by around 10%, resulting in increased ore production. With less manpower required for fully-mechanized mining, the labour cost was saved by CNY 9.75 million per year (CNY 0.15 million/person/year).

The development of intelligent subsystem market was boosted. Based on the average price of CNY 0.6 million of an intelligent subsystem, replicating the solution on 30 mines can create an additional income of CNY 140 million.

For the 5G industry, the incubation of planning-deployment-optimization services will not only lower the threshold of converging 5G with various industries, but also expand project services to bring up the 5G service market share by 15% approximately.

Social benefits

For the industry and companies, intelligent subsystem deployment has responded to the needs for less or even no workers or reduced workload in some underground jobs. Now, centralised monitoring and operation are possible aboveground for some jobs, with the underground equipment status being managed and controlled by the centralised control centre to provide greater operational safety. With the shift in the way of working, miners have changed from blue collars to white collars, who can now work in a risk-free environment that reassures their families and society. Consequently, the comfortable working environment aboveground will facilitate talent introduction and improve the competitiveness of mining roles.

Moreover, the planning-deployment-optimization services incubated by Xinyan Coal Mine via releasing eight subsystems have provided substantial support for the convergence of 5G with the coal industry, introducing new growth drivers for 5G and industrial applications.

Summary and Next-Steps

The solution to the challenges of adopting 5G industrial applications is to "benefit multiple stakeholders." The Xinyan Coal Mine project would not be successful without the support from the operator China Mobile and the equipment vendor Huawei who are key drivers of the project. China Mobile Shanxi sent a team to the coal mine shortly after winning the open bid for the 5G communication system project of Xinyan Coal Mine in July 2020. Three months later, the team delivered an integrated aboveground and underground 5G private network after completing the installation and commissioning of all 55 sets of equipment. In November 2020, Xinyan Coal Mine carried out the first remote mining of underground intelligent working faces via China Mobile's 5G private network, with a safe production of 11 cuts of coal in a single shift totalling around 10,000 tons, which marked the fulfilment of all-weather remote control of production. Huawei also supported Xinyan Coal Mine and China Mobile in the exploration and innovation of project requirements. During MWC Shanghai 2021, Huawei, China Mobile Shanxi, and Xinyan Coal Mine jointly launched a 5GtoB PNI-NPN kite-like solution. Based on the business profiling, fast integration, and collaborative optimisation in service innovation, the 5G requirements of each business system

were accurately measured and translated into network planning to standardise the integrated implementation of mining scenarios, and ensure that key indicators such as network rate, latency, and reliability meet business needs.

In this project, various intelligent subsystem applications were brought online via a single underground 5G network, realising the leap from "feasibility" to "productivity" in 5G network deployment, and promoting the evolution of 5G network and the incubation of industry service capabilities. For the industry and Xinyan Coal Mine, the convergence of 5G with intelligent applications has just begun, and there is still a long way to go before the booming development of industrial intelligent applications. The third phase of the Xinyan Coal Mine project will continue the focus on the convergence of 5G with industrial applications and further deepen the construction of smart mining by launching 19 5G-based applications including the intelligent tunnelling face with integrated driving and anchoring. In addition, Xinyan will advance the network evolution and functional optimization during application release, and improve planning, deployment, and optimization as well as follow-up operation and maintenance services, contributing to the development of 5G + smart mining.