

西山煤电-以利用促抽采降低煤矿瓦斯风险最佳实践

Xishan Coal Electricity - Application of CMM Best Practices and CMM Risk Reduction



贺志宏 先生 西山煤电总工程师

Mr. He Zhihong, Chief Engineer of Xishan Coal Electricity

March 2022

目录 Catalogue

1. 西山煤电概况 Company Profile

2. 瓦斯综合治理 CMM control

3. 瓦斯综合利用CMM Utilization project

4. 科技创新及十四五规划Technological innovation and the 14th Five-year Plan

1. 西山煤电概况 Company Profile

前身是原西山矿务局，成立于1956年

山西焦煤集团的核心子公司，全国最大的炼焦煤生产基地

拥有27对矿井，9座选煤厂，13座发电厂，3座焦化厂，两座水泥厂，职工61498人

2021年原煤产量5070万吨，精煤产量2016万吨，焦炭产量482万吨，发电量214亿度

Formerly known as Xishan Mining Bureau, founded in 1956.

A core subsidiary of SCCG, the largest coking coal production base in China.

With 27 mines, 9 coal preparation plants, 13 power plants, 3 coking plant, 2 cement factories, employees 61,498.

In 2021, 50.7 Mt raw coal production, cleaned coal 20.16 Mt, coke coal 4.82 Mt tons, electricity production 21.4 billion kWh.



2、瓦斯综合治理 CMM Control

2.1 瓦斯治理理念和模式 Concept, Mode of CMM Control

2.2 瓦斯治理新技术 New Technology of CMM Control

2.3 三维仿真通风系统 3D simulation of ventilation system

2.1 瓦斯治理理念和模式 Concept, Mode of CMM Control

为有效治理瓦斯，西山煤电提出了“556”瓦斯治理新理念、新模式，即：In order to effectively control gas, Xishan put forward the new concept and model of "556" gas control, namely:

5:五项工作制度:

(1)瓦斯超限追查问责制度;

(2)矿井通风系统管理制度;

(3)“三区联动”瓦斯治理制度;

(4)“一矿一策，一面一策”瓦斯治理制度;

(5)技术创新引进保障制度。

Five working mechanism:

(1)the tracing system for overlimited on VAM;

(2) management on ventilation system ;

(3) "three linkage" gas control system;

(4)"one mine with one policy, one policy with one LW" for gas control;

(5) introduced technological innovation system.

2.1 瓦斯治理理念和模式 Concept, Mode of CMM Control

5: 五项瓦斯治理技术:

- (1) 煤层预抽增透技术;
- (2) 大直径煤柱钻孔代替横贯及沿空留巷“Y”型通风治理上隅角瓦斯技术;
- (3) 底抽巷治理下邻近层瓦斯治理技术;
- (4) 大孔径顶板走向长钻孔代替高抽巷技术;
- (5) 地面“U”型预抽钻井及采动裂隙带地面“L”型抽采钻井技术

Five CMM control technology:

- (1) Permeability increasement for in seam pre-drianagele;
- (2) Large diameter borehole replaced cut through for Upper conner control;
- (3) Gas control technology for under seam from bottom Gallery;
- (4) Roof Large diameter borehole replaces top galary;
- (5) Promote the "U" type drainage drilling and surface "L" type to fructuree zone technology.

6: 六项装备应用:

- (1) 可视化三维通风仿真模拟系统应用;
- (2) 瓦斯抽采钻孔施工“一钻一视频”应用;
- (3) 瓦斯抽采动态达标评判系统应用;
- (4) 定向钻机应用;
- (5) 地面瓦斯抽采系统应用, 取消井下移动泵站;
- (6) 千米钻机消突技术应用。

Six Applications:

- (1) The visual 3d ventilation simulation system application;
- (2) Borehole construction "a borehole with a video "application;
- (3) Dynamic evaluation system for gas drainage;
- (4) Directional drilling applications.
- (5) Ground gas drianage system, remove underground pumping station;
- (6) Outburst control by long directional drilling.

2.2 瓦斯治理新技术 New Technology of CMM Control

1--煤层水力割缝卸压增透技术

利用高压水射流作为冲击动力来源，给煤层内部卸压、为瓦斯释放和流动创造了良好的条件，增大了煤层的透气性能。

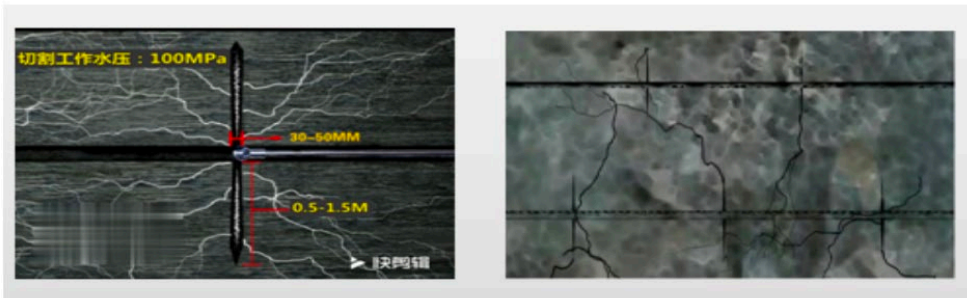
Hydraulic unloading slot technology:

High pressure water jet cutting is a kind of make full use of high pressure water as power source, impact to the internal pressure relief, for gas release of coal seam and the flow created good conditions, increase the permeability of coal seam.



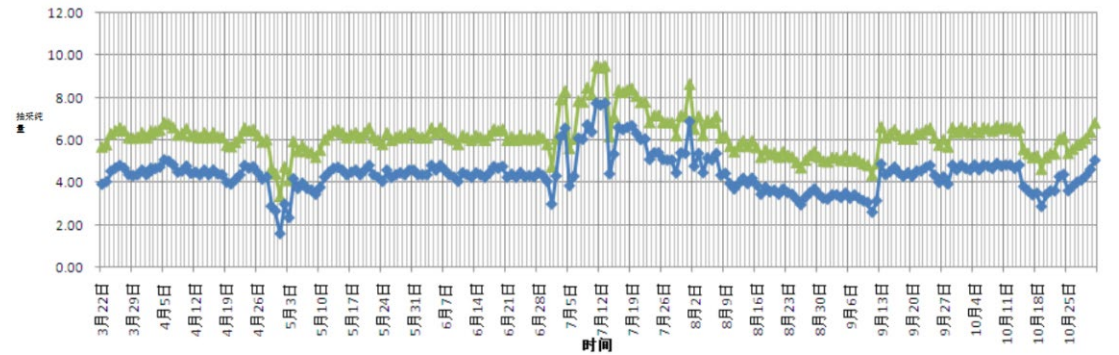
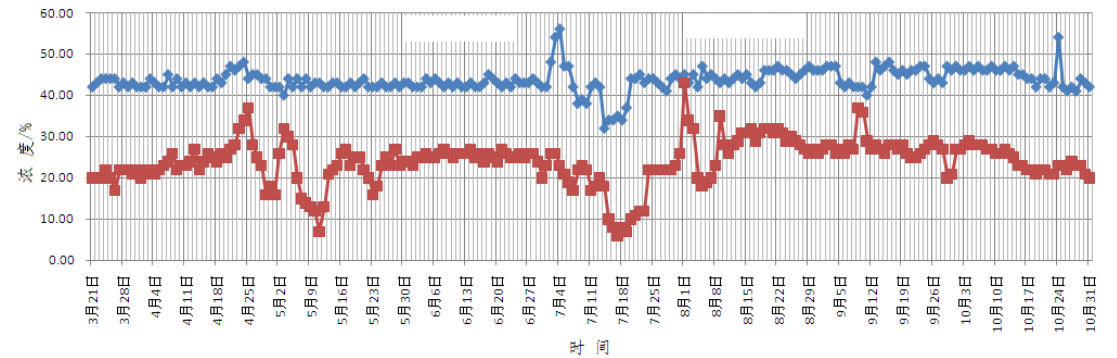
(a) 钻孔施工

(b) 切割出水



(c) 切割缝隙

(d) 煤层增透



实施该技术后，抽采纯量提高了2.13m³/min

After the implementation of this technology, the pure extraction volume increased by 2.13m³/min

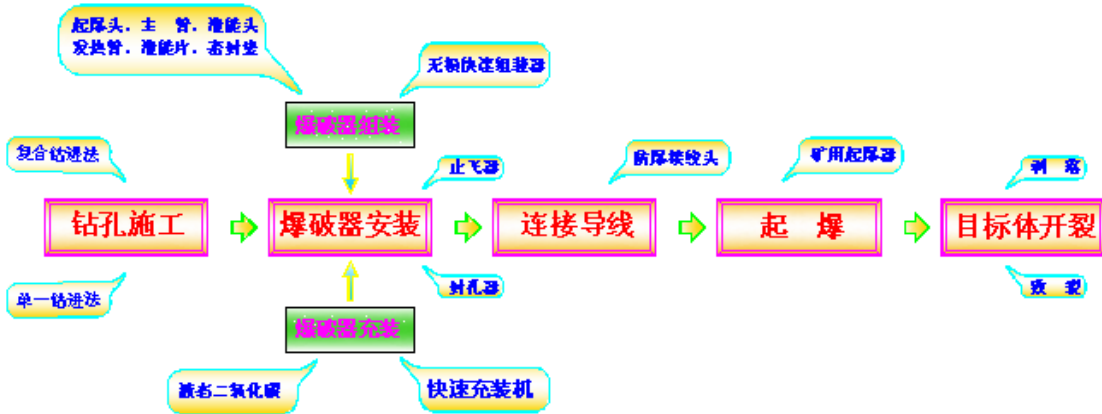
2.2 瓦斯治理新技术New Technology of CMM Control

2--液态CO2爆破增透技术

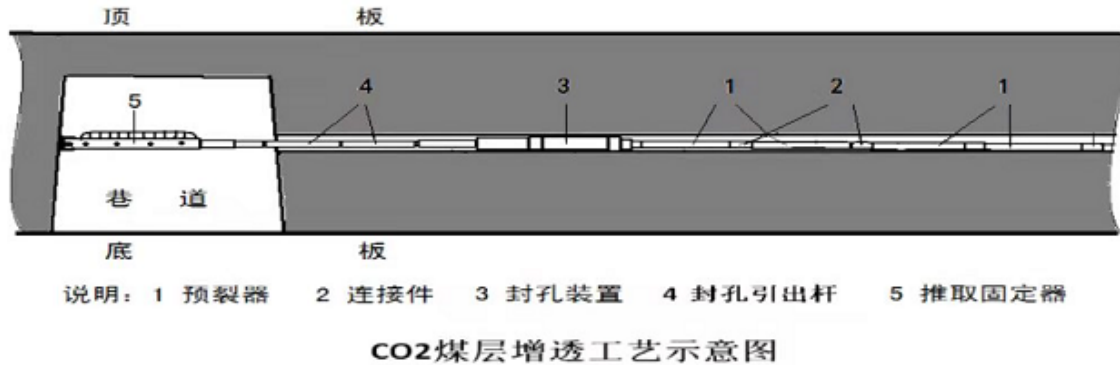
通过液态CO2气化瞬间产生强大的冲击波和膨胀将煤体撑裂，使煤体内的原生裂隙得以扩展，并产生大量的新裂隙，增强煤层的透气性。

Liquid CO2 blasting technology:

CO2 enhance extraction technology measures is through liquid CO2 gasification and instantly have a powerful shock waves and expansion to brace crack of coal, the coal body native crack expand, and generate a lot of new cracks, increase coal seam permeability.



2.2 瓦斯治理新技术New Technology of CMM Control



采用CO₂预裂的本煤层钻孔单孔平均瓦斯抽采量较未预裂钻孔提高了2.2倍。抽采半径达超过2.5m以上。

The average gas capture of single hole in this coal seam drilling with CO₂ pre-splitting is 2.2 times higher than that of drilling without pre-splitting. The extraction radius is more than 2.5m.

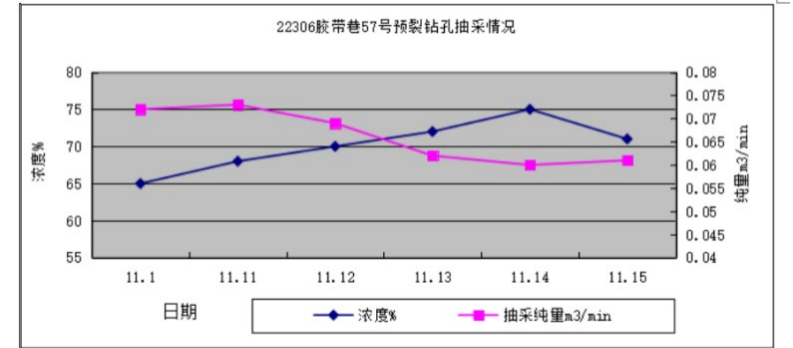


图 10 22306 工作面 57#预裂钻孔瓦斯抽采情况图

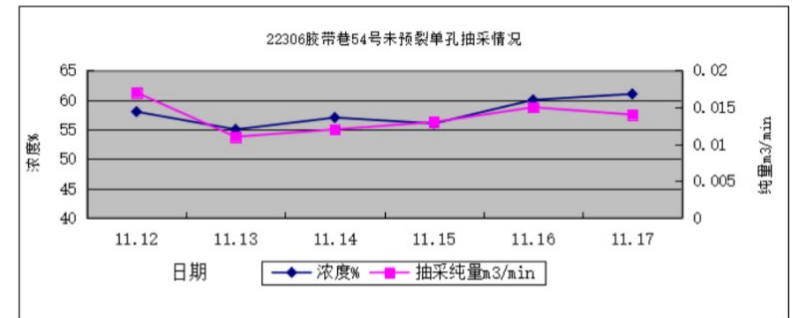


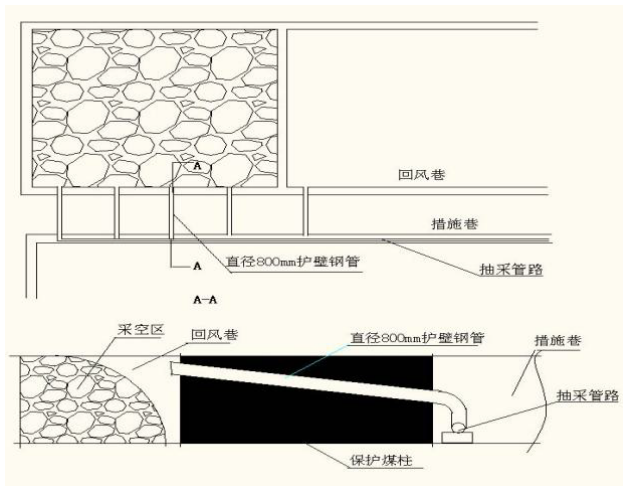
图 11 22306 工作面 54#未预裂钻孔瓦斯抽采情况图

2.2 瓦斯治理新技术 New Technology of CMM Control

3--大直径钻孔替代横贯技术 Large diameter borehole replaced cut through for Upper conner control:

利用“U+L”型通风系统，在原横贯位置施工大直径钻孔，变风排瓦斯为抽排瓦斯。采用螺旋钻进方式，从邻近巷道每隔30m左右，在垂直保护煤柱内向回风巷施工直径为500mm的大直径钻孔，钻孔中插入护壁的大直径护管，在钻孔两端进行封孔，替代横贯对采空区进行低负压、大流量瓦斯抽采。

With "U + L" type ventilation principle, replaced the cut-through to large diameter borehole. at intervals of about 30 m in vertical protection coal pillar to return with large diameter borehole diameter of 500 mm with standpipe , sealing the hole at both ends, with low negative pressure, large flow gas drainage.

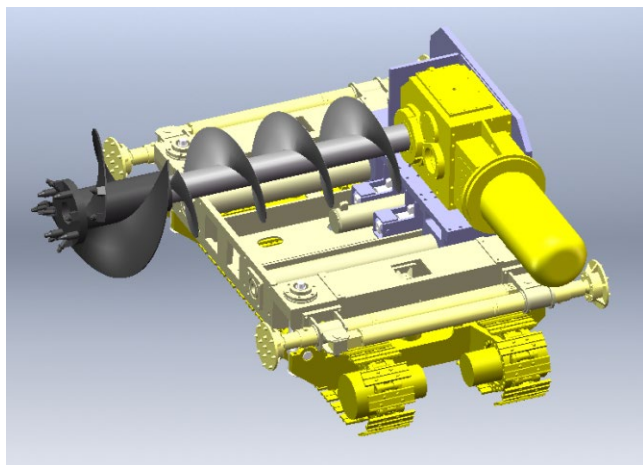


采用大直径钻孔替代横贯埋管抽采，大大降低采空区瓦斯抽采成本，实现了低负压、大流量稳定抽采采空区瓦斯，大幅度降低回采工作面的瓦斯涌出量，彻底解决回采工作面采区瓦斯涌出量大和上隅角瓦斯超限的问题

Reduce the cost of gas problem in goaf, with low negative pressure and large flow, greatly reduce the gas emission during of mining, and completely solve the problems in upper corner of LW face

2.2 瓦斯治理新技术New Technology of CMM Control

500mm的大直径钻机，钻头，钻杆详见下图：500mm large diameter driller, bit, rod see the figures below



采用大直径钻孔替代横贯埋管抽采，大大降低采空区瓦斯抽采成本，实现了低负压、大流量稳定抽采采空区瓦斯，大幅度降低回采工作面的瓦斯涌出量，彻底解决回采工作面采区瓦斯涌出量大和上隅角瓦斯超限的问题

Reduce the cost of gas problem in goaf, with low negative pressure and large flow, greatly reduce the gas emission during of mining, and completely solve the problems in upper corner of LW face

2.2 瓦斯治理新技术 New Technology of CMM Control

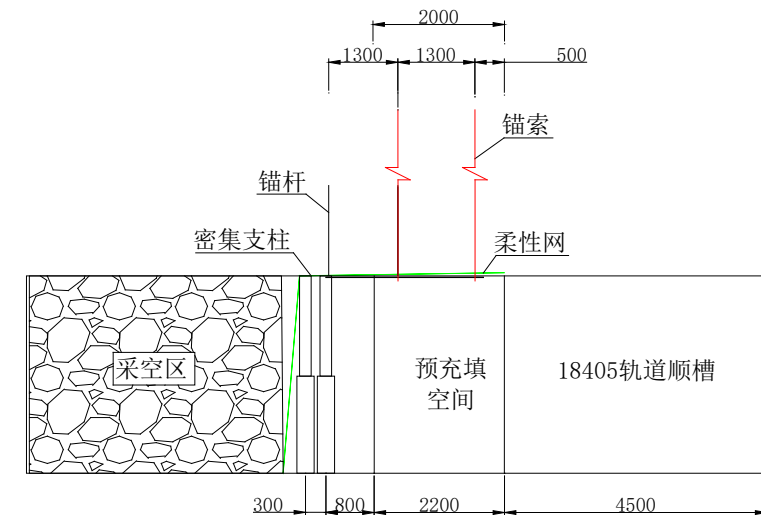
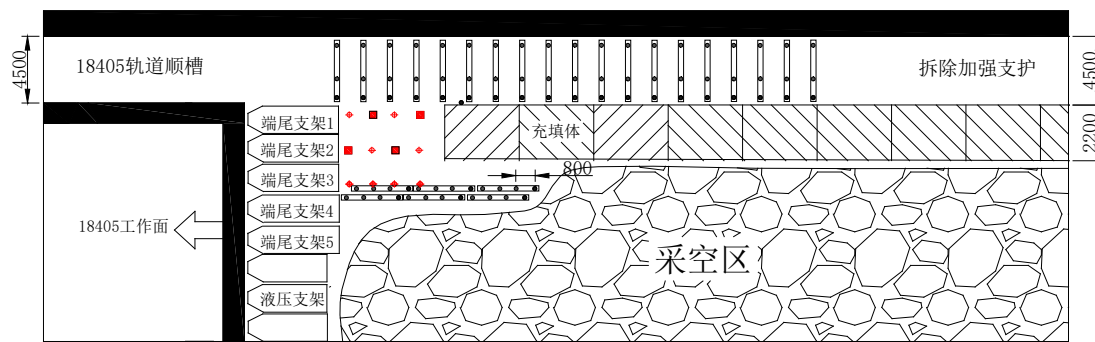
4--沿空留巷Y型通风技术 Gob-side entry retaining technology for Y type ventalation:

使用高水材料做充填体，沿采空区保留一条巷道，形成“Y”型通风系统，能有效解决上隅角瓦斯超限的问题。High water material is used as filling and a roadway is reserved along the goaf to form a "Y" type ventilation system, which can effectively solve the problem in the upper corner.

高水材料沿空留巷技术的优势： Advantage of High-water quick consolidated filling materials:

(1) 工艺系统简单、初期投资少 (2) 可长距离输送、机械化程度高 (3) 充填体能适应顶板下沉，保持留巷的整体稳定性

(1) process system is simple, less initial investment (2) for long-distance transmission, high mechanization degree (3) filling physical fitness roof subsidence, maintain the overall stability of the left lane

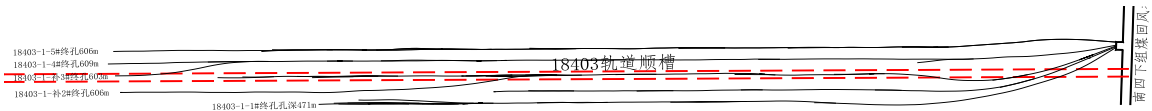


2.2 瓦斯治理新技术 New Technology of CMM Control

5--定向长钻孔煤层区域瓦斯抽采技术 Directional long borehole in coal seam area for roadway Developing

通过在煤层中施工定向长钻孔对待掘区域实施瓦斯预抽，降低工作面掘进过程中的突出危险性。

Pre-drainage in coal seam with directional long drilling to reduce the outburst risk in roadway developing.



钻孔编号	见煤米数	钻孔总长度	开孔倾角	开孔方位角	瓦斯浓度(%)	接抽纯量 (m3/min)
No. 1	753	966	-1.2°	198°	82	0.22
No. 2	459	471	-1.4°	207°	84	0.20
No. 3	1100	1155	0.3°	209.1°	91	0.28
No. 4	903	966	-3°	219.8°	85	0.25
No. 5	804	858	4.1°	236.4°	90	0.22

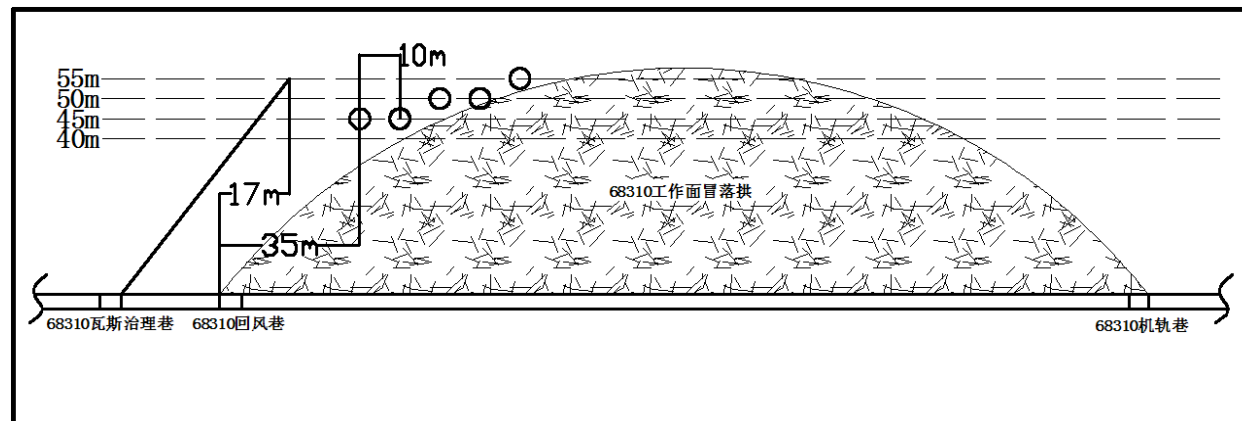
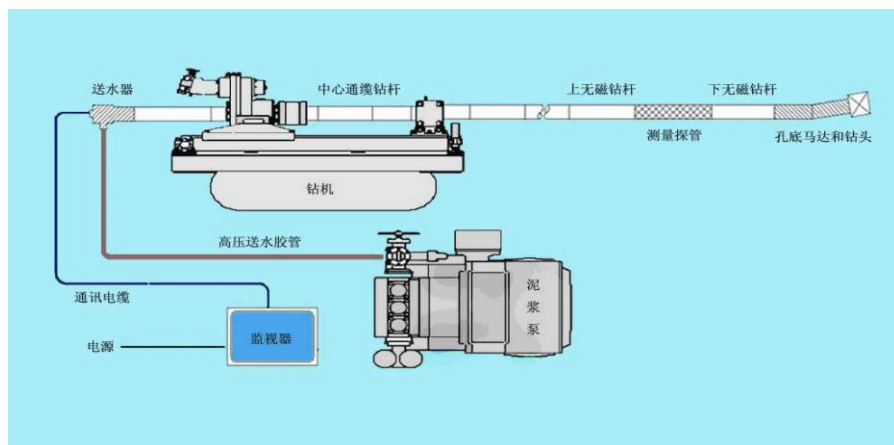
抽采后，对应区域残余瓦斯含量降低由为13.4m3/t至5.4 m3/t，保障了巷道的正常掘进。The residual gas content in the corresponding area decreases from 13.4m3/t to 5.4m3 /t, ensuring the normal developing of the roadway.

2.2 瓦斯治理新技术New Technology of CMM Control

6--顶板大孔径钻孔代替高抽巷抽采技术Roof Large diameter borehole replaces top gallery

利用大功率定向钻机向煤层顶板裂隙带施工大孔径定向长钻孔代替高抽巷，抽采上邻近层卸压瓦斯，以提高采空区瓦斯抽采效果、减少回采工作面瓦斯涌出量。

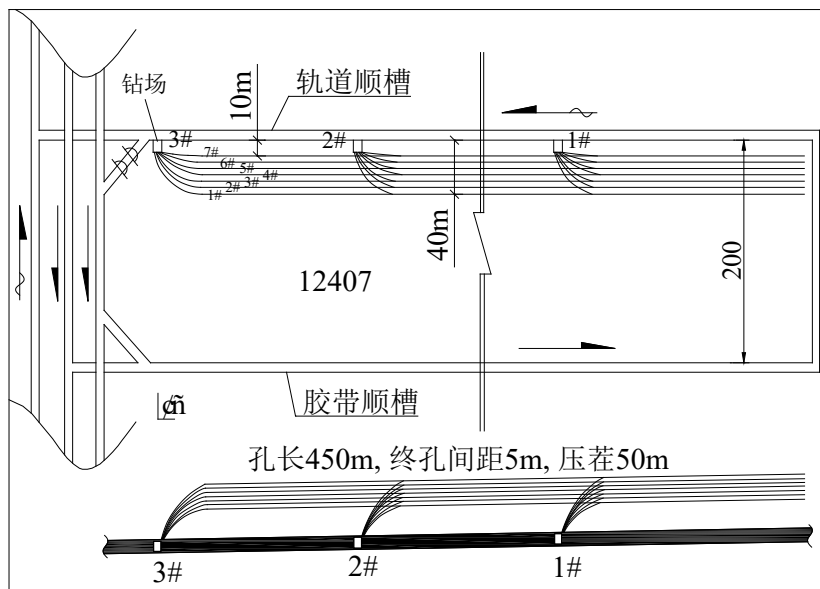
With high-power directional rig for gas control in fracture zone, which replace top Gallery, to improve the performance of gas control in goaf and reduce the gas emission from working face.



2.2 瓦斯治理新技术 New Technology of CMM Control

与高抽巷相比，顶板走向长钻孔的施工量小，成本低，钻孔布置更灵活。

Compared with top gallery, the construction is less, the cost is low, and more flexible.



正常回采时，单孔瓦斯浓度保持在40%~50%。

经济成本：一个工作面高抽巷的成本费用大约是顶板走向长钻孔的1.5~3倍。

施工工期：施工一条980m长的巷道，两者相比工期上相差接近3倍。

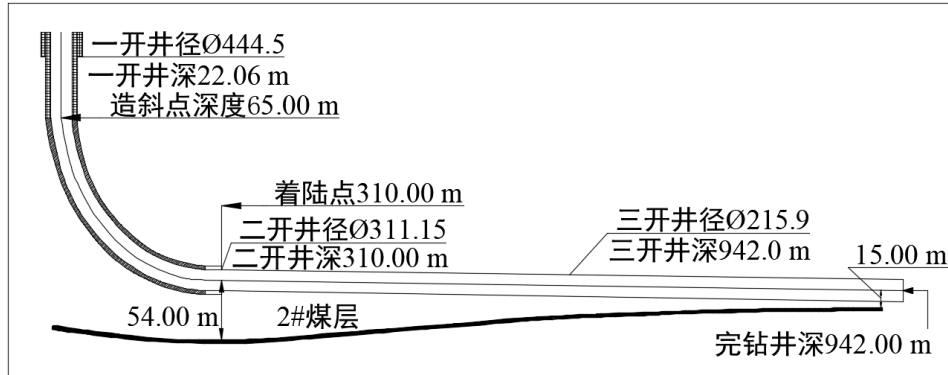
During normal mining, the gas concentration of single hole remains at 40% ~ 50%.

Economic cost: the cost of a working face high gallery pumping costs about 1.5 ~ 3 times that of roof toward the long borehole. Construction time limit for a project: a 980 m long tunnels, compared to the time limit for a project of the two is nearly three times.

2.2 瓦斯治理新技术 New Technology of CMM Control

6--地面L型采动钻井瓦斯抽采技术 Surface L - type mining drilling technology:

在实施井下顶板走向长钻孔代替高抽巷抽采的同时，为进一步破解治理工程受井下巷道空间限制的难题，西山矿区开始实施地面L型采动钻井代替高抽巷抽采。the Surface L-shaped mining drilling is implemented in Xishan mining area instead of Top Gallery.



对比项目 Items	地面L型采动钻井 Surface L - type	高抽巷 Top Gallery
成本 (万元/m) Cost (10 Thousand RMB/m)	1	1.5
单进 (m/月) Construction speed (m/month)	400	80
工程价值 Purpose	一井多用 Can be used for multiple purpose	工作面回采后封闭报废 scrapped after mining
采掘平衡 Contribution for production	与井下生产活动在不同空间和不同时间实施，大大缓解生产衔接紧张的被动局面 beneficial to improve production efficiency	采掘接续紧张 Its tight nbetween developing abnd mining

2.2 瓦斯治理新技术New Technology of CMM Control

西山近年使用的瓦斯抽采钻机详见下表：

The drilling RIGS used in recent years are shown in the table below:

大功率定向钻机参数High Power directional drilling rig parameters				
钻机型号Model	孔径diameter (mm)	孔深Depth (m)	额定功率Rated power (KWh)	额定转矩Rated torque (N·m)
ZDY-12000LD	120	600	132	12000
ZDY-15000LD	193	600	132	15000
ZYL-17000LD	203	650	132	17000
ZDJ10000	550	60	132	10000



VL1000 (ZYL-23000) 千米定向钻机，先后在意大利、中国、美国和俄罗斯等国家投入使用



轻量级CHD708SCHD908HPT，钻杆的耐磨性和强度远高于普通同规格钻杆。



直径3m，可用深度270m，12000N·m的定向钻机，可以适用于VL1000，ZYL2000等定向钻机。



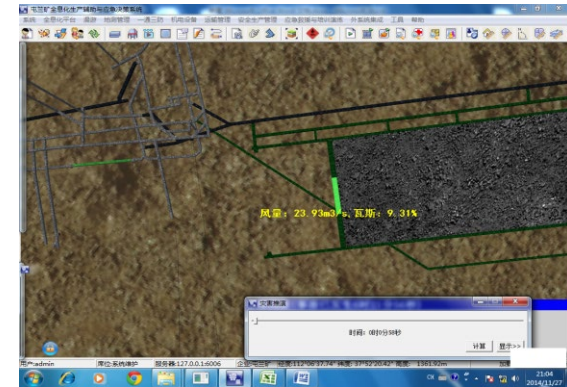
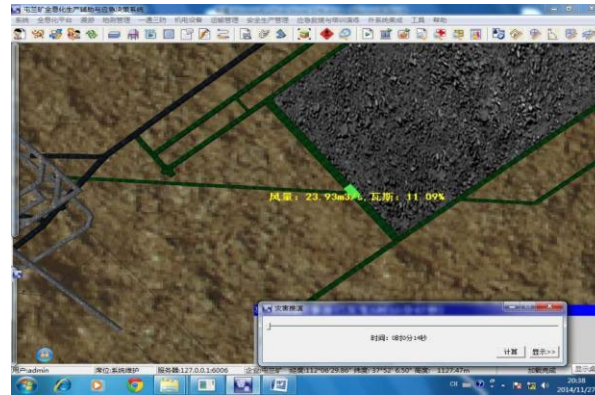
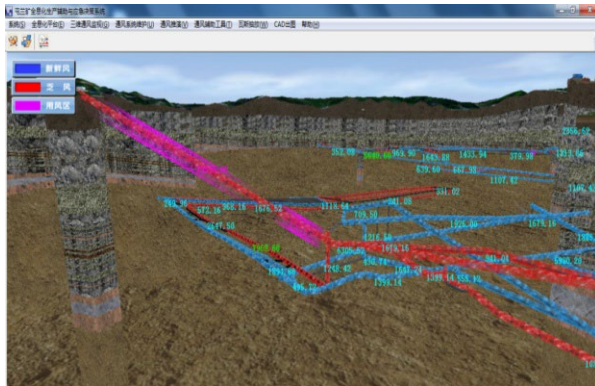
世界最先进，最可靠，最精确的定向定向孔定向钻机，适用于任何复杂的地下生产环境。

2.3 三维仿真通风系统 3D simulation of ventilation system

三维仿真模拟通风系统 3Dsimulation of ventilation system:

矿井三维通风动态仿真模拟系统通过三维建模，将复杂的通风参数和通风过程以三维动态图形的方式简单、直观的展现出来，通风技术人员可随时模拟和调整通风系统，实现巷道风量分配的实时解算和分析，提高了矿井通风管理人员的决策水平。为煤矿防灾救灾提供了科学手段。

Through the three-dimensional modeling, show the ventilation in the form of 3 d dynamic graphics, ventilation technician can simulate and adjust ventilation system to get real-time computation and analysis of roadway ventilation distribution, improve management. It provides scientific method for coal mine disaster prevention and relief.



3、瓦斯综合利用CMM Utilization project

3.1 瓦斯利用理念 Concept of CMM Utilization

3.2 瓦斯利用发展历程History of CMM Project

3.3 瓦斯利用案例分析 Case study of CMM Project

3.1 瓦斯利用理念 Concept of CMM Utilization

瓦斯利用理念: CMM utilization concept:

西山煤电秉承“以减排促利用，以利用促抽采，以抽采保安全”的瓦斯抽采利用理念，制定完善《瓦斯抽采及瓦斯发电运行考核办法》，对相关矿井及瓦斯发电进行考核，进一步确保了瓦斯利用项目的高质量建设和高效运行，瓦斯发电项目运行指标均为一流水准。

Xishan addressing the concept of "to promote utilization with Emission Reduction, promote capture with utilization , ensure safety with CMM drainage" constantly perfect the measures for the assessment of gas extraction and gas power generation, carries on the inspection of the mine and the gas power generation, to further ensure the quality of the gas utilization project construction and run efficiently, gas power generation project running indexes for first-class standard.

2021年度Year of 2021	抽采量万m3 CMM drainage 10 Thousand m3	利用量Utilization 万m3/10 Thousand m3	利用率 Ratio of utilization %	备注 Rermark
西山煤电Total in Xishan	26800	11240	41.9	
杜儿坪矿瓦斯电站 Duerping	5078.1	1682.51	33.13	
西铭矿瓦斯电站Ximing	1830.19	1183.44	64.66	
官地矿瓦斯电站Guan Di	2695.43	400.00	14.84	
马兰矿瓦斯电站 Malan	4392.56	1855.10	42.23	
东曲矿瓦斯电站 Dongqu	2971.9	1209.30	40.69	
屯兰矿矸石山高浓电站Tunlan High %	9498.3	2679.29	51.70	
屯兰矿矸石山低浓电站Tunlan Low %		872.23		
屯兰矿白草塔高浓电站 Bai Cao Ta		1359.10		



3.2 瓦斯利用发展历程History of CMM Project

2007开始，西山煤电与辛迪克开展国际合作，利用CDM机制，引进国外资金、技术、设备开发了世界级的杜儿坪煤矿瓦斯利用项目、马兰煤矿煤矿瓦斯利用项目、屯兰煤矿瓦斯气煤矿瓦斯利用项目。

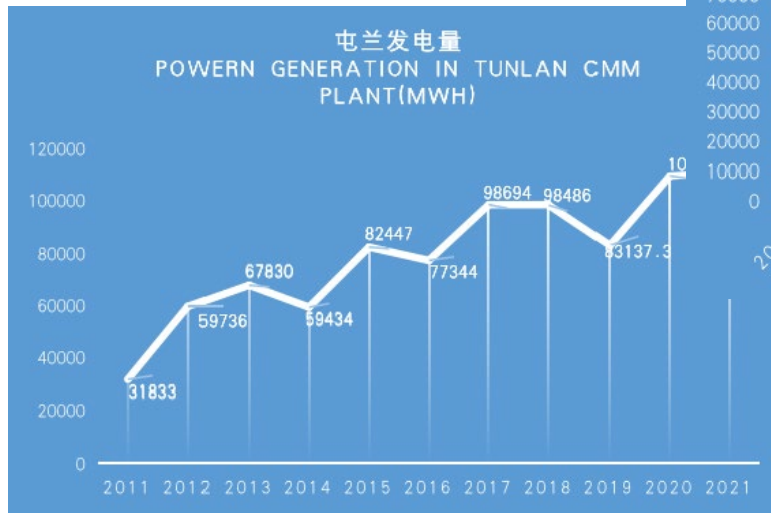
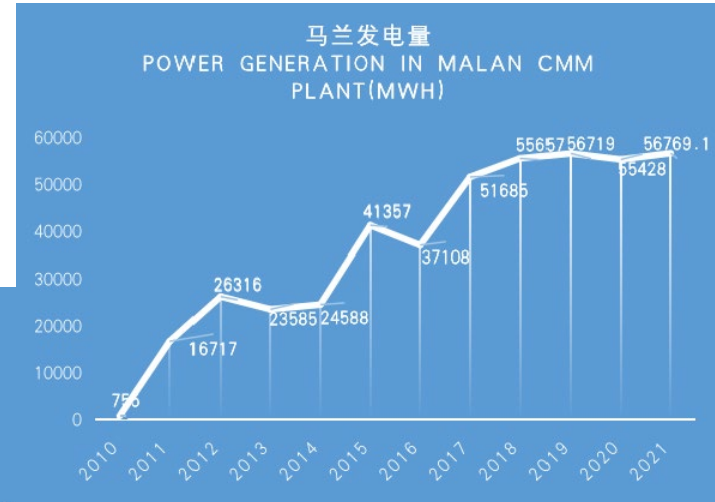
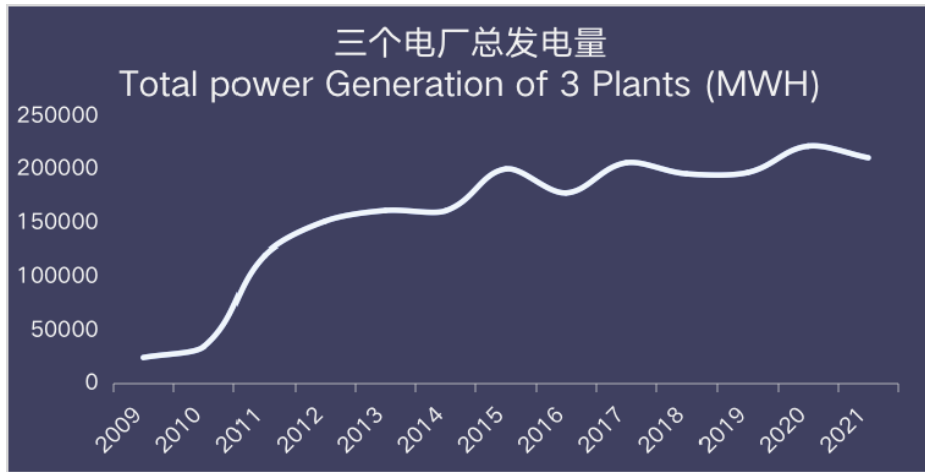
Since 2007, Xishan has cooperated with Sindicatum, based on CDM, using foreign funds, technology and equipment, have successively developed world-class gas utilization projects in Duerping Coal mine, Malan Coal mine and Tunlan Coal mine.



3.2 瓦斯利用发展历程History of CMM Project

3个项目一直稳定运行，发电量/瓦斯消耗量/发电效率一直处于国内领先水平，发电量稳步增加每年保持在2.1亿度以上。

The three projects have been running stably, and the power generation/gas consumption/power generation efficiency has been at the leading level in China. Electricity generation has steadily increased to over 210 million KWH per year.



3.2 瓦斯利用发展历程History of CMM Project

新的瓦斯利用项目不断开发：New gas utilization projects are being developed

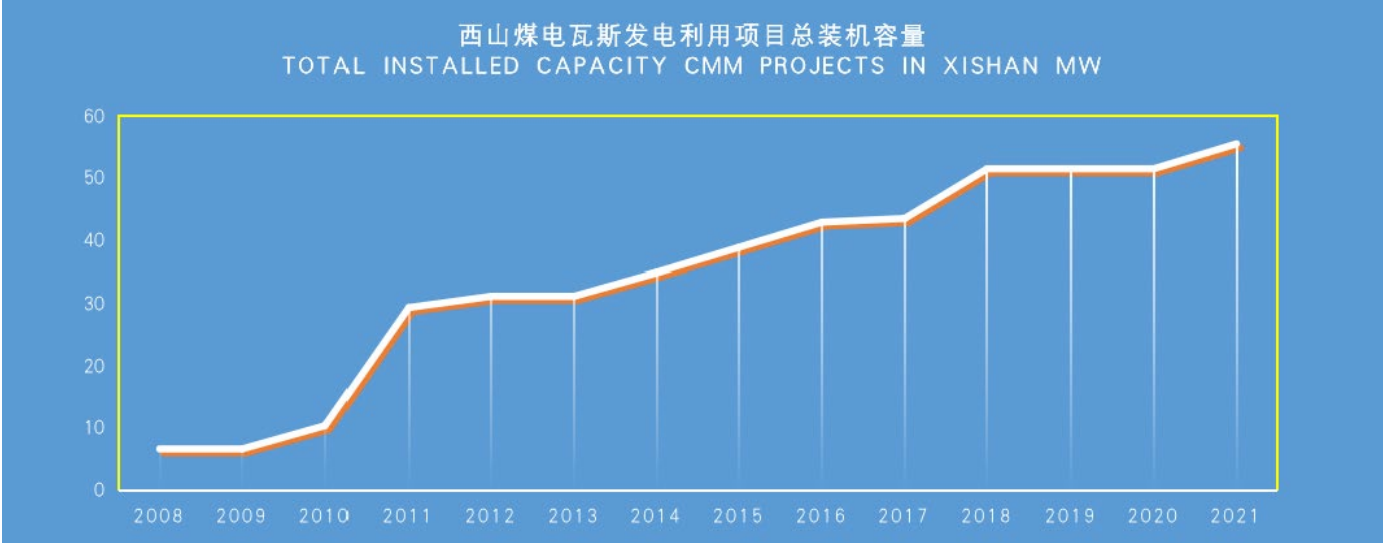
包括：西铭矿、官地矿、东曲矿、屯兰矿白草塔、屯兰矿矸石山低浓等瓦斯利用项目。Including: Ximing , Guandi , Dongqu, Tunlan Baicaoata, Tunlan low concentration gas utilization projects. 各项目的装机容量详见下表 The installed capacity of each project is shown in the table below:

杜儿坪 Duerping	马兰Malan	屯兰Tunlan	东曲瓦斯电厂Dongqu
8515	7480	16180	3300
西铭瓦斯电厂Ximing	屯兰低浓度瓦斯电厂 Tunlan Low CH4	白草塔瓦斯电厂Baioaota	官地瓦斯电厂Guandi
4000	4000	8000	4000



3.2 瓦斯利用发展历程History of CMM Project

截止到2021年，西山煤电瓦斯发电项目总装机容量为55.48MW。 By 2021, the total installed capacity of Xishan coal-power gas power generation project is 55.48MW.



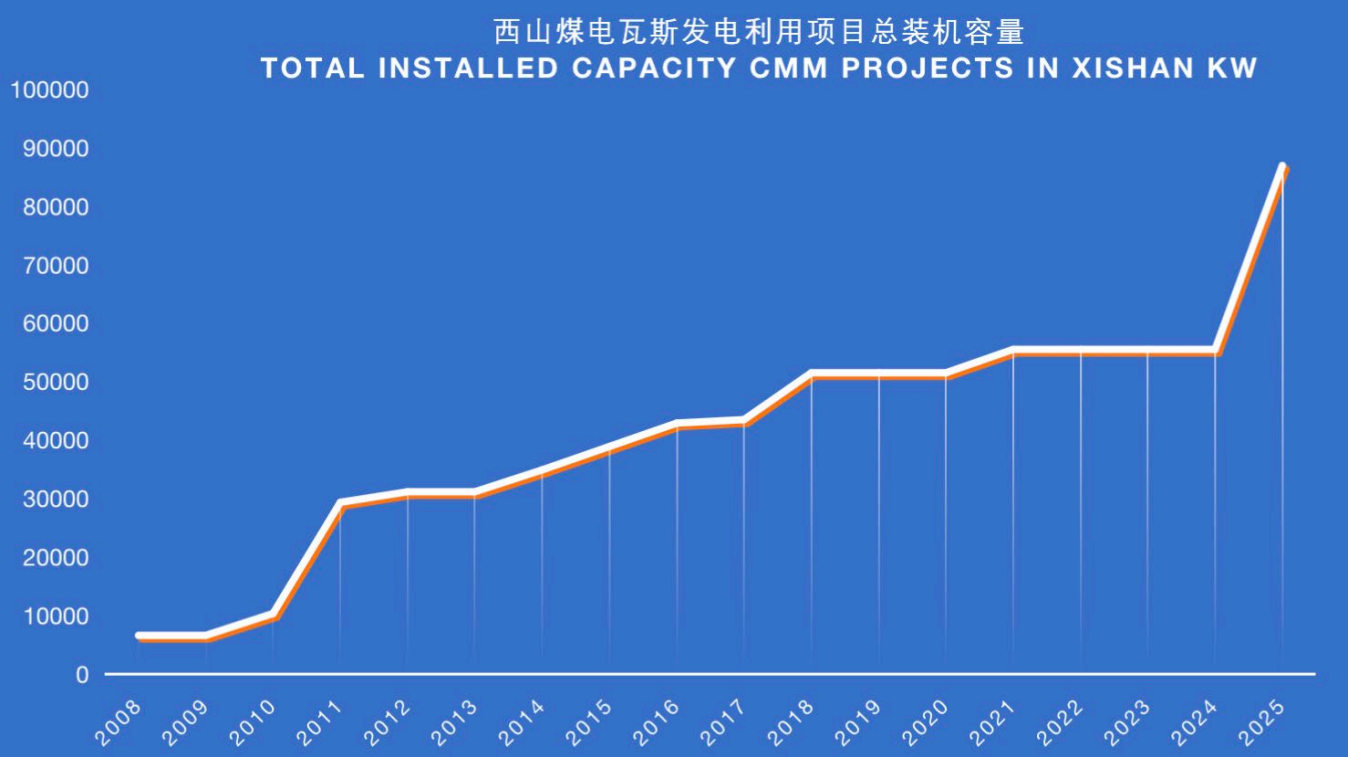
西山煤电目前瓦斯发电项目年收益1.05亿元，其中发电电价收益8500万元、瓦斯利用补贴2000万元。10年累计发电收益7.56亿元、获得瓦斯气补贴2.03亿元。

The annual revenue of Xishan Coal and Power gas power generation project is 105 million yuan at present, including 85 million yuan of electricity generation revenue and 20 million yuan of gas utilization subsidy. In the past 10 years, the accumulative power generation income has reached 756 million yuan and the gas subsidy has reached 203 million yuan.

3.2 瓦斯利用发展历程History of CMM Project

根据规划，到2025年，西山煤电的瓦斯电站达到13座，总装机规模达到85MW。届时，年发电量约为5亿度，年瓦斯利用量将达到1.7亿m3以上，高浓瓦斯利用率达到85%以上。

According to the plan, by 2025, there will be 13 gas power stations in Xishan coal power station, with a total installed capacity of 85 MW, power generation will be around 500 Million KWH per year, CMM utilization will reach more than 170 million m3 per year, and utilization rate of high concentration will reach more than 85%.

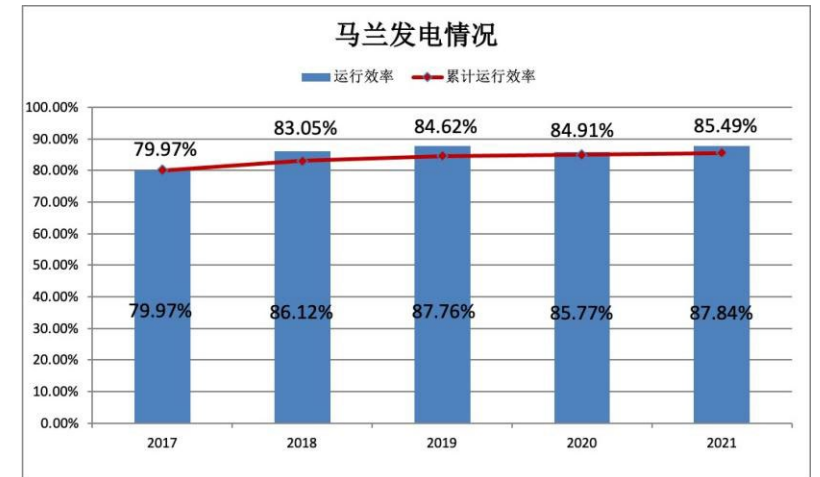
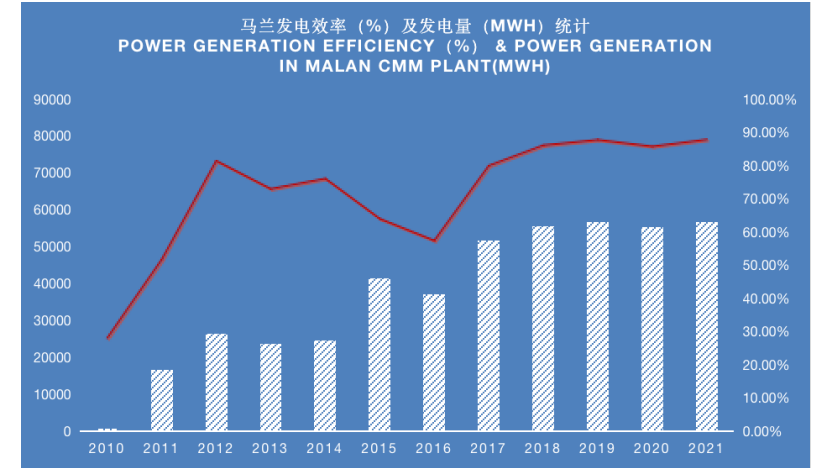


3.3 瓦斯利用案例分析 Case study of CMM Project

马兰高浓瓦斯发电厂示范工程 Malan CMM demonstration project

2021年马兰瓦斯发电厂运行情况 Operation of Malan CMM Plant in 2021

项目名称 Plant	设计规模Design Capacity MW	投资总额Investment (万元/10 Thousand RMB)	2021年利用减排情况 Utilization and emissions reductions in 2021			
			利用浓度CH4 (%)	利用量 utilization (Nm3)	减排量emissions reductions i (万 吨/10 Thousand ton)	发电量 (万度) Power produced (10 Thousand KWH)
马兰瓦斯电厂 Malan	7.480	7700	≥30%	1855.1万	31	5676.89



马兰瓦斯发电项目一直维持在80%以上高效运行，达到国际先进水平。Malan CMM Plant has been maintained at more than 80% efficient operation, reaching the international advanced level.

2021年，1#机组“在国际品牌高浓度瓦斯机组单机连续运行时间第一名”，马兰瓦斯电厂获得山西省瓦斯发电协会2021年度“行业POWER奖”荣誉。

In 2021, engine 1 ranked first in single continuous operation time of international brand high concentration gas unit, and Malan CMM Plant won the honor of "Industry POWER

4. 科技创新及十四五规划 Technological innovation and the 14th Five-year Plan

4.1 近年科技创新情况 Technological innovation in recent years

4.2 瓦斯抽采利用十四五规划 14th Five-year Plan on CMM control and utilization

4.1 近年科技创新情况 Technological innovation in recent years

西山煤电围绕着矿井瓦斯治理利用的关键技术，开展了一系列科学研究，取得了中国煤炭工业协会、山西省科技厅等多个奖项，包括：Xishan has carried out a series of scientific researches on key technologies of mine gas control and utilization, and has won many awards from China Coal Industry Association and Shanxi Provincial Science and Technology Department, including:

- 1、《古交矿区煤与瓦斯突出危险快速辨识技术及应用示范》获得2021年获煤炭工业协会科技进步二等奖"Rapid Identification Technology and Application Demonstration of Coal and gas Outburst Danger in Gujiao Mining Area" won the second prize of Science and Technology Progress of China Coal Industry Association in 2021
- 2、《基于大数据框架下瓦斯灾害分析与综合治理技术精准优选研究》获得2020年煤炭工业科技进步三等奖"Research on Gas Disaster Analysis and Precise Optimization of Comprehensive Treatment Technology based on Big Data framework" won the third prize of scientific and Technological Progress in coal industry in 2020
- 3、《近距离煤层群瓦斯精准抽采关键技术与工程应用》获得2020年煤炭工业协会科技进步一等奖" Key Technology and Engineering Application of accurate Gas control in Close Coal Seam Group" won the first prize of Science and Technology Progress of China Coal Industry Association in 2020



4.1 近年科技创新情况 Technological innovation in recent years

4、《大孔径煤柱穿层钻孔代替横贯埋管技术研究》获得2019年山西省“五小六化”竞赛一等奖

Research on Technology of Replacing Cross-buried Pipe by Drilling through Coal Pillar with Large Aperture won the first prize of "Five small and Six Chemical" competition of Shanxi Province in 2019

5、“屯兰矿瓦斯赋存与涌出规律研究及煤与瓦斯突出防治体系建立”获得2011年度中国煤炭工业协会科学技术二等奖

"Research on gas occurrence and Emission law of Tunlan Mine and Establishment of Coal and gas Outburst Prevention System" won the second prize of Science and Technology award of China Coal Industry Association in 2011

6、“煤矿瓦斯抽放管道抑爆阻火技术及装备研究”、“瓦斯分源立体抽采及综合利用一体化关键技术”获得2013年度中国煤炭工业协会科学技术二等奖

"Research on Explosion and Fire Suppression Technology and Equipment of Coal Mine Gas Drainage Pipeline", "Key Technology of Gas Separation and Three-dimensional Drainage and Comprehensive Utilization Integration" won the second prize of Science and Technology award of China Coal Industry Association in 2013.

7、“杜儿坪矿密闭巷道-钻孔联合预抽技术研究”获得国家安全生产监督管理总局科学技术二等奖

Research on the Combined Pre-pumping technology of Closed roadway-drilling in Duerping Mine" won the second prize of Science and Technology award of the State Administration of Work Safety



4.2 瓦斯抽采利用十四五规划14th Five-year Plan on CMM control and utilization

西山煤电“十四五”瓦斯抽采利用规划 The 14th Five-year Plan

1、成立综合性研究机构 Establish comprehensive research institutions

联合重庆大学、中煤科工、中国矿大、河南理工、安徽理工申报“山西省瓦斯抽采和综合利用一体化技术创新联盟”，力争建成稀缺资源绿色智能开采、矿井伴生资源综合利用等技术创新联盟。

Jointly with Chongqing University, China Coal Science and Technology, China University of Mining Technology, Henan Institute of Technology and Anhui Institute of Science and Technology to apply for the "Shanxi Province Gas Extraction and Comprehensive Utilization Integration Technology Innovation Institute", and strive to build the green intelligent mining of scarce resources, comprehensive utilization of mine associated resources and other technical innovation institute.

2、提高煤矿瓦斯抽采利用率 Improve the utilization rate of CMM

加大煤矿瓦斯和矿井乏风利用力度，加大开展废弃（关闭）矿井瓦斯开发利用力度，最大限度地减少煤矿甲烷排放。

Will increase the utilization of CMM and VAM, intensify the development and utilization of AMM, and minimize methane emissions from coal mines.





谢谢! THANKS