

Chapter 8

The Datong Coal Mine Group Ltd and Its Tashan Circular Economy Park: A Business Case

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1. Introduction

Although circular economy has been introduced to China only in the last few years, it has gradually become a concrete practice in the country's economic and social life and a national development model.

The development mode of regional circular economy in China, determined by its development stage, technical and economic conditions, resources and environment, and external development, is shown in three different models: (i) the spontaneous strategic transformation model in the developed areas of the eastern coast (Shanghai, Jiangsu, Shandong, etc.); (ii) the regional strategic transformation from extensive development mode into sustainable development mode in the northeast areas (Liaoning, Jilin, etc.), China's old and heavy industrial bases that have economic and technical foundation; and (iii) a resource-based strategic transformation model in the midwest areas (Shanxi, Guiyang, etc.), rich in mining resources but have less-developed technology and weaker economic foundation. Moreover, China has carried out pilot work on circular economy at three levels: (i) vigorous promotion of clean production at the enterprise level, (ii) creation of eco-industrial parks at the industrial level, and (iii) circular economy demonstration projects in pilot provinces and cities.

From actual situations, the practice of circular economy in China is still at the stage of experiment and demonstration. The more successful cases are mostly concentrated at the enterprise level involving large enterprises offering good benefits and have relatively advanced technology. State-owned enterprises located in key areas and key nodes of circular economy and with relatively advanced technology and talent advantages are being considered to play a vanguard role in leading and promoting small and medium-sized enterprises in jointly developing circular economy. Some large state-owned enterprises are developing circular economy not only through clean production process but also through the formation of eco-industrial parks to achieve resource recycle and zero emission. The circular economy park is a concept based on clean production and consists of a series of manufacturing enterprises and



service-oriented enterprises. They share resources and exchange symbiotic products through industrial chain networks to achieve material recycling, energy recycling, full utilisation of wastes, and, ultimately, zero emission.

This paper chooses the Datong Coal Mine Group Ltd, a large resource-based state-owned enterprise in China's midwest area, and its Tashan circular economy park as example of circular economy practice.

Coal is one of the major energy resources in China, accounting for approximately 70 percent of the country's primary energy consumption. Coal occupies more than half of China's energy structure and remains the main component in the country's energy structure in a long time. With an annual coal production capacity of 35 percent of the world's total annual capacity, China has become the largest coal producer in the world, with 11.67 percent of recoverable coal reserves of the world's total.

As the energy demand in China continues to rise dramatically, the demand for coal also continues to increase. With China's industrialisation and the fast development of its economy, the economic loss to the environment and resources has become even larger. Many environmental problems and risks to human health arise during coal exploitation, utilisation, and waste disposal, especially in the remote mountainous areas of China. In response to the record-high levels of air pollution in 2012 and 2013, the State Council issued in September 2013 the Action Plan for the Prevention and Control of Air Pollution as it reiterated the need to reduce coal's share in China's energy mix to 65 percent by 2017.

Under a low-carbon situation, the sustainable development of the coal industry faces great challenges as meeting carbon-intensity target requires a significant change in trajectory for carbon emissions and coal consumption. This requires China to adopt an integrated management approach to resolve the conflict between industrial development and environmental protection. The concept of circular economy serves this purpose.

The Datong Coal Mine Group Co Ltd is one of the hard-coal production leaders in China. Its green practice in the Tashan Circular Economy Park has been recognised as leading the development of the nation's coal industry and can be applied nationwide. Thus, in the case study, we analyse the development process of circular economy in resource-based enterprises, and summarise the basic experiences and challenges that a Chinese enterprise undergoes in developing circular economy. Several suggestions are then put forward.



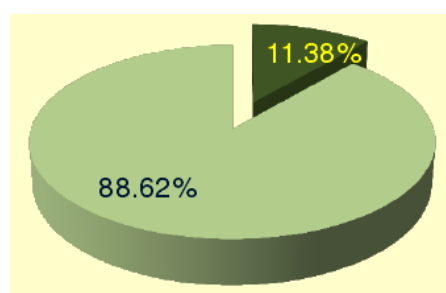
2. Circular Economy Development in the Datong Coal Mine Group Co Ltd: Strategy and Situation

2.1. Brief Introduction of the Datong Coal Mine Group Co Ltd

The Datong Coal Mining Administration, established in 1949, was the predecessor of the Datong Coal Mine Group before it was restructured as the Datong Coal Mine Group Co Ltd in 2000. It is located in the southwest part of Datong City, and its coal mines are scattered mainly in Shanxi Province and the Inner Mongolia Autonomous Region. It is a super-large comprehensive energy group, with coal production as its mainstay while featuring the simultaneous development of various industries such as power, coal chemical, metallurgy and coal machinery manufacturing, construction and building materials, logistics and foreign trade, etc. The Datong Coal Mine Group has a long history of coal mining, with the development and use of its coal resources dating back to the end period of the Ming Dynasty. Over the past 62 years since it was established, the company has turned out a total of more than 2.1 billion tonnes of coal.

The corporation mainly extracts weak caking coal from the Jurassic period. This coal has low ash and sulphur content, high calorific value, moderate volatilisation, and stable quality. In 1989, the company set coal industry standards to help develop itself into a modern enterprise. It won the National Golden Horse Corporate Management Prize and the National May Day Labor Prize. In 1992, it ranked first among the 100 best-known enterprises, according to the *China Enterprise News*, the *Enterprise Management* magazine, and the Enterprise Management Press. The company is a leader in scientific development and technologies for the coal industry and its technology centre is among the top 100 institutions, attaining the highest standards and gaining approval from the State Economic and Trade Commission.

Figure 8.1. The Proportion of Coal and Non-coal Industry in the Datong Coal Mine Group in 2002



Coal (88.62%) No coal (11.38%)
Source: Datong Coal Mine Group Data.

However, the group's extensive growth pattern of high input, high consumption, high pollution, and low benefit to the enterprise later led to resource depletion and environmental degradation. The group's development faced a serious threat as it was mainly dependent on extensive production. While the volume of coal production remained very big, the product



conversion rate was low and associated with short industry chain with low value-added production.

Thus, the leaders of Datong Coal Mine, standing at the height of the enterprise strategy and the national development requirements, decided to develop a circular economy park to change the traditional mode of production and form a more environment-friendly development path by adopting a more scientific mode and method of production.

In 2003, Datong Coal Mine started to construct the Tashan Circular Economy Park about 30 km south of the city of Datong and 20 km from its headquarters. Put to use in 2009, it is the first park built by Datong Coal Mine in line with the 'reduce–recycle–reuse' principle. It is also the first of circular economy demonstration projects in Shanxi Province and is currently considered one of the typical and successful cases.

2.2. Circular Economy Park in the Datong Coal Mine Group Co Ltd: SWOT Analysis

The Tashan Circular Economy Park takes a sustainable development road and promotes the harmonious development of social economy and ecological environment. Based on the resource, environment, location, and social and economic conditions, the park aims to scientifically lay out the industry chain nodes in support of new energy-saving and emissions-reduction technologies, design multistage recycling circulation, and reuse wastes to protect the environment and reduce the hazards of emissions through clean and recycling production, with 'black coal mining, green park development, high carbon industry, and low carbon emission' as some sort of slogan.

The circular economy park mode is a kind of industrial symbiosis with the mining industry as the core and part of the middling cycle. It turns wastes, energy, and by-products that cannot be digested in one mining enterprise into raw materials or power of another enterprise. The mining industry couples transversely and shares resources with different industry departments – such as power generation, chemical, light, and construction industries – to form an enterprise network so that materials, energy, and information can flow harmoniously. A SWOT analysis, which measures the strengths, weaknesses, opportunities, and threats to an enterprise, can help understand the corporation's strategy and the challenges it faces in the development of circular economy.

(1) Strengths

- **Resource and location advantage:** The Datong Coal Mine Group is well known at home and abroad for its multipurpose soft coal with less than 10 percent ash, less than 1 percent sulphur, and a 28-megajoule/kg calorific capacity. It is of industrial fines and a quality brand steam coal in the world. The Datong coal, as it is known, has been chosen as one of 'China's 10 most internationally influential brands', one of the 'annual top-10 Chinese brands on the world market', and a 'national inspection-free product'.



- **Market advantage:** The Datong Coal Mine Group has a very high market ratio. Its clients include various industries in China, including power, metallurgy, building materials, and other industries. It also exports to many countries such as Japan, Republic of Korea, India, and Turkey. It annually exports 10 million tonnes of coal and, to date, has produced a total of 945 million tonnes of quality coal and paid CNY11.7 billion (US\$1.85 billion) in taxes, the highest in China's industry sector, and 2.5 times the total government investment/spending. According to the company's annual operating income report, Datong Coal Mine ranked 341st of the World's Top 500 in 2015, 70th of China's top 500 companies, and 7th of China's top 100 coal mine enterprises in 2014.
- **R&D and human resource advantages:** The Datong Coal Mine Group enjoys a prominent position in the country's mining industry because of its professional, management, and technical teams. After years of investment in science and technology research and development (R&D), the company now boasts of advanced coal-mining technology, such as low-caving coal mining, short-range coal seam fully mechanised coal mining, thin-coal layer of plow mining, etc., and owns a large number of independent intellectual property rights, patents, and technological achievements. It has created more than 100 number one honours in China and was awarded 168 scientific and technological progress prizes above the provincial and ministerial levels. The company has a national technical centre and six postdoctoral mobile stations. Its science and technology contribution to coal production ranks first in the coal industry. Datong Coal Mine has 41 of its experts awarded the special allowance by the State Council, four awarded as 'national technicians', and a hundred senior personnel as recipients of provincial and ministerial awards.
- **Relatively complete industrial chain:** Datong Coal Mine's present setup includes major categories of coal, electricity, coking coal, coal chemical, carbon, fertiliser, and building materials. The main products of these categories include steam coal, washed coal, electricity, coke oven gas, coal tar, clumsy, synthetic ammonia, urea, methanol, compound fertiliser, super-high power graphite electrode, f brick, coal seam gas and cement, etc.
- **Capital comparative advantage:** The Datong Coal Mine Group has two publicly listed corporations: Zhangze Power Plant and Datong Coal Industry Co. Through issuance of corporate bonds, finance listing in capital market, establishment of financial companies, and enhanced strategic cooperative relations with large domestic commercial banks, Datong Coal Mine has increased its capital accumulation and attracted more and more investment-strategic partners.

However, we should also see that coal prices may drop because of the emergence of excess coal production capacity, and mining cost may increase because of the introduction of national resource tax laws. In certain circumstances, the Datong Coal Mine Group's financial comparative advantage may disappear.



(2) Weaknesses:

- **Possible depletion of coal reserves:** The Jurassic coal resources are now severely depleted. Half of the coal mines of the Datong Coal Mine Group are near to depletion and six have gone bankrupt because of resource depletion. Based on the present rate of coal mining, coal resources in 10 mines may be exhausted within 5 years and another 20 mines in 6–15 years. The coal resources the Datong Coal Mine Group is extracting at present are carboniferous resources. Due to their high ash and sulphur content, carboniferous coal resources are easily impacted by market fluctuations. Once the market demand is changed by the economic situation, product sales will be severely affected.
- **Relatively slow transformation of the industry:** The size and the unit capacity of the Datong Coal Mine Group's electric power plants are small and easily affected by the demand of electric power market. The production capacity of the coal chemical industry is backward. The market volatility of methanol-related products and semi-coke-related products is big, and the anti-risk ability is weak. Compared with domestic and foreign counterparts, Datong Coal Mine's coal machine equipment manufacturing industry is not competitive.
- **Heavy social burden:** As an old mining company, the Datong Coal Mine Group has a large ratio (up to 1:2.5) of retirees and in-service staff and needs to pay a huge amount of pension each year. The Datong Coal Mine Group bears the social burden of staff education and health care, community and logistics services, and others. Heavy social burden has become a big challenge for enterprise development. In the near future, through strengthened interaction with the government, the Datong Coal Group's existing weaknesses may turn into relative advantages.

(3) Opportunities

- **National development of circular economy:** In 2005, the State Council pointed out the future development direction of the coal industry by encouraging the integration of coal industry, accelerating the construction of large electric power plants, alleviating the pressure of coal transportation, and promoting clean coal technology industry development (Guo Fa, 2005). In the 12th Five-Year Plan, the state strongly supports the merger and reorganisation of coal enterprises, optimisation of industrial structures, elimination of backward production capacity, and improvement of coal production intensification. It gives priority to resource follow-up and coal project approval. To curb excessive investment, the central and local governments have made policies to integrate resources within the coal industry by closing down small coal mines and developing middle-sized and large ones.



- **Middle and Western Great Exploitation Strategy:** The central region has a comparative advantage in the energy and manufacturing industries, and will continue to play a crucial role in the industrial transfer from the eastern region. The Western Great Exploitation Strategy and the new Belt Road also provide new development opportunities in the eastern and western regions. The state will continue to increase support for policy, capital investment, and industrial development in the central and western regions.
- **A national resource-based economic transition testing area of Shanxi Province:** As a comprehensive transformation pilot area, Shanxi Province, China's largest resource-based economy, can obtain more policy space in developing circular economy. As Shanxi Province has accelerated transformation and development in recent years, it can provide Datong Coal Mine more funding and policy support in its green development progress.
- **China's industrial structure adjustment:** With the contradiction between supply and demand of coal prominently increasing, the joint mergers and acquisitions among coal and coal-associated industries such as electric power, iron and steel, and building materials are likewise increasing as both seek common development. This is bound to be a great opportunity for developing large coal industry innovation, financing, and capital operation.
- **Support to develop new coal chemical and other strategic emerging industries:** China has considered the development of new coal chemical industry as an important strategic measure for energy security. Furthermore, the state is pushing the cultivation and development of strategic emerging industries. The government is already entering into China's venture capital industry and establishing a CNY40 billion (US\$6.5 billion) fund to help seed companies in emerging industries, mainly those into energy saving, environmental protection, emerging information industry, bio industry, new energy, new energy vehicles, high-end equipment manufacturing, new materials, etc. The Datong Coal Mine Group has the natural resource, financial advantage, and certain technical force in the new coal chemical industry development. If the new coal chemical demonstration projects are successful, the enterprise will face a major transformation and development opportunities. It will also provide new opportunities for the company to develop diversified industries, especially on new energy, new materials, energy saving, and environmental protection.

(4) Threats

- **The overall downturn in the coal industry:** In the past 10 years, an overheated market attracted too many investors to the coal industry. The integration of resources in China, through closing down of the small mines and expansion of the large ones, has lured more investment into the coal industry. This has caused overcapacity and low price. Excessive



production may push current overcapacity situation to even more embarrassing levels. This will inevitably affect the coal enterprise's investment in clean coal technology.

- **External competition:** The aggregation of China's energy industry can greatly improve the degree of concentration of the coal industry and enhance the reliability of a steady supply of coal. But it can also challenge the Datong Coal Mine Group's possession of resource, expansion of traditional market scale, and maintenance of new market.
- **Heavy environmental pollution and ecological fragility pressure:** Due to long-term overexploitation, the damage to the ecological environment is very serious. Geological disasters, air pollution, water pollution, and solid waste pollution have directly affected the mining area's production and life (Figure 8.3). The amount of gangue as intractable solid waste adds up to 80 million tonnes, occupying 266.7 hectares, and forming hundreds of coal gangue hills. Spontaneous combustion of coal gangue has produced a large number of harmful gases, seriously threatening water, air, and soil. Thus, how to comprehensively utilise coal gangue has been given increasing attention (Guo and Zhu, 2011). Based on the industrial output per capita and waste discharge data in 1993, 1994, and 2000–2005, the waste water, waste gas, and solid waste emissions are exhibiting an uptrend with the increase in the per capita output.

Figure 8.2. Wasted Coal Gangue 'Mountain' and the Surface Crack Caused by Coal Mining



Source: Datong Coal Mine Group.

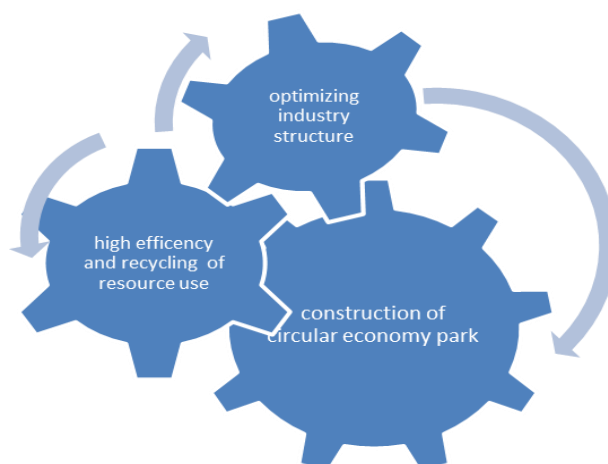
- **Low resource recovery rate:** A large number of abandoned secondary products and serious waste exist. Resource recovery rate on the average is less than 50 percent, with large waste of the residual coal reserves and associated secondary resources or coal gangue.

2.3. Development Strategy of the Datong Coal Mine Group Co.

Considering the strengths, weaknesses, opportunities, and threats that the Datong Coal Mine Group is currently facing, the enterprise development strategy is obvious: improve mining efficiency, diversify industrial structure, and achieve recycling of resources and green development.



Figure 8.3. Three Steps to Achieve the Green Strategy of the Datong Coal Mine Group Co Ltd



Source: Datong Coal Mine Group.

During the 12th Five-Year Plan (2011–2015) period, under the guidance of scientific outlook on development and centred on the overall deployment of transformative development of Shanxi province, the Datong Coal Mine Group's development thinking was to thoroughly carry out the corporate strategic development system of (i) renovating and upgrading the traditional industries, (ii) extending and expanding the pluralistic industries, and (iii) developing and strengthening the new industries. The development mode can be concluded as 'black coal, green mining; circular economy, full utilisation; high-carbon industry, low-carbon technology'. The development goal was to speed up the building of a modernised comprehensive energy group characterised by circulation, low carbon, environment friendliness, and harmony.

The most important means to achieve green development of the overall enterprise is to build circular economy parks. The Tashan Circular Economy Park is taking the lead in promoting the harmonious development of social, economic, and ecological environment.

3. Characteristics of the Datong Coal Mine Group's Tashan Circular Economy Park

Covering a floor space of 387 ha and with the total investment of CNY20.4 billion, the park had been planned to set up two coal mines, 10 factories, and one railway for coal exporting. Construction of the park started in 2003 and was finished in August 2009. It is the first circular economic park in nature with the most complete industrial chain, the fastest construction, and the most obvious effect on China's coal industry.



3.1. Clean Mining and Production

The park uses asymmetric mine development philosophy to achieve resource efficiency. It has an overall mining plan to exploit the coal resources in carboniferous Permian instead of the lower surface of the Jurassic mine area. The park has a supporting coal preparation plant for clean production of steam coal. The plan for improving efficiency and decreasing the environmental impact of mining is broken up into the following:

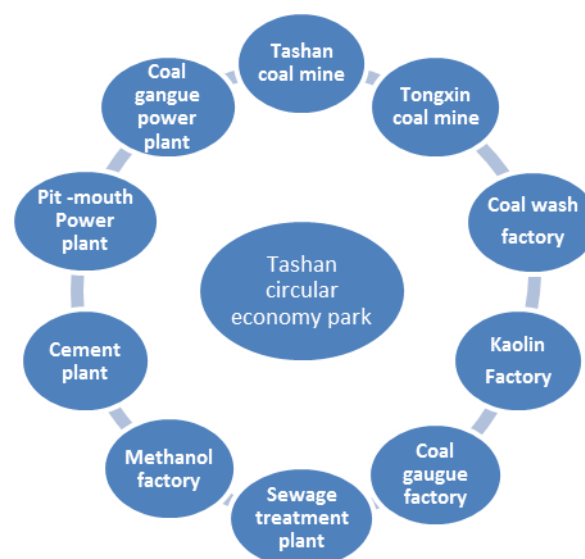
- Shutting down illegal and unregulated mines
- Choosing environment-friendly general mining processes
- Implementing recently discovered green mining technologies
- Cleaning up the sites of shut-down mines
- Re-evaluating cut-off grades
- R&D in green mining technology

3.2. A Closed-Loop Flow of Both Material and Energy

3.2.1. Complete industry chain

The park has 10 projects: two coal mines with annual output of 15 million tonnes; a coal-preparation plant; a kaolin-processing plant; a coal gangue brick factory; a sewage-treatment plant with daily processing capacity of 4,000 cubic metres; a methanol project with annual output of 1.2 million tonnes; a cement clinker production line; a pit-mouth power plant, and a coal gangue power plant. Furthermore, the park owns a self-support railway connected with the Beijing–Baotou Railway, the Datong–Puzhou Railway, the Datong–Qinghuangdao Railway, and several city expressways.

Figure 8.4. Tashan's 10 Projects to Achieve Closed-Loop Material Flow



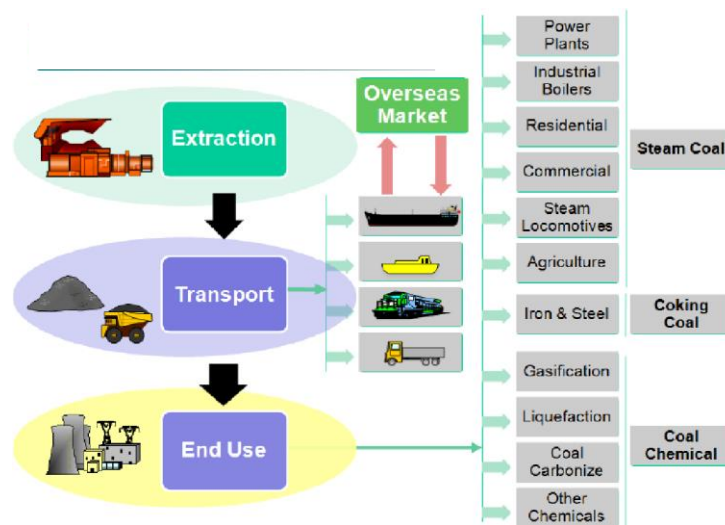
Source: Datong Coal Mine Group document.



3.2.2. Waste to energy

The washed coal is transported via special railways. The middling and small coals are used in the chemical processing of coal to produce methanol. The coal gangue separated by the preparation is transported to the brickyard and the coal with low calorific value is transported to the power plant to generate electricity. Coal and coal products pass through all activities of the chain from upstream to downstream sectors and gain some value at each activity.

Figure 8.5. Value Chain of the Coal Industry



Source: Dan (2014).

3.2.3. Waste and resource recycling

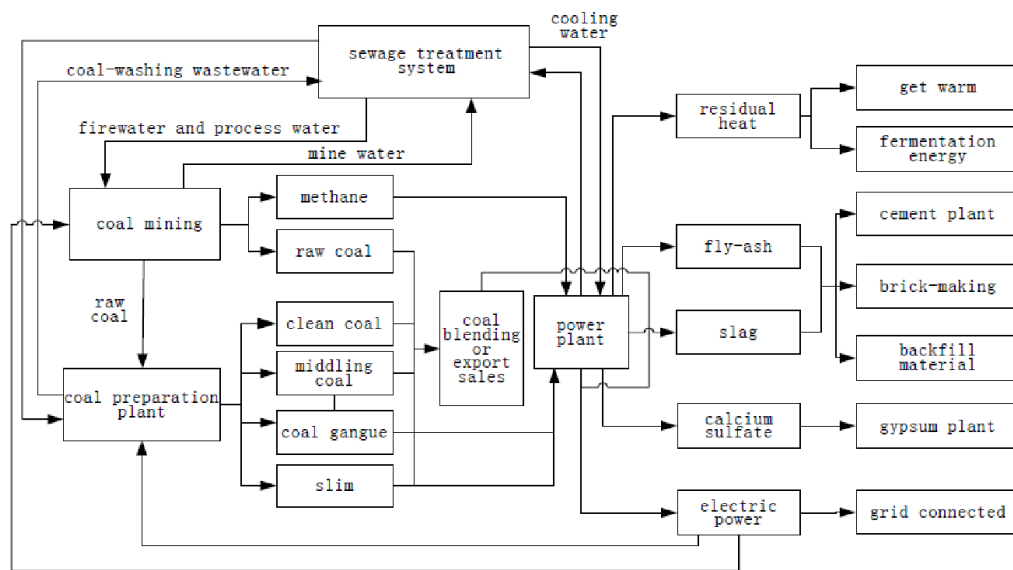
The park has two circular economic industrial lines: coal-electricity-building materials and coal chemical industry, where washed coal is transported by special railway. Residual coal pieces are used to produce methanol, coal rubble is separated and transported to a factory to make bricks, and low-value coal is used by the power plant to generate electricity. The excess heat from the power plant is used to heat residences in the area. The fly ash discharged by the pit-mouth power plant is used as raw material for the cement plant, and the kaolinic shale produced by the excavation of coal is raw material for kaolin.

In the circle, waste from the upstream plant is used as raw materials of the downstream. It constitutes a closed-loop material flow as 'mineral resources–mineral products–waste–renewable resources' according to mineral exploration, exploitation, processing, melting, deep processing, consumption, and other processes. In this way, the environmental, social, and economic benefits of the park are clearly demonstrated. Figure 8.6 illustrates how the solid coal waste can be reused.



Figure 8.6 also shows the compound purification treatment of mine waste water. Increased waste water is produced in coal mining, including underground geological water, natural groundwater for safety production, and grime waste water caused by sprinkling, falling dust, fire retarding grouting, and fire-fighting and hydraulic equipment. The mineral chemical composition and geological environment deeply affect the characteristics of mine waste water, especially hydrogeology condition and water-filling factor which determine water quality and quantity.

Figure 8.6. Circular Model of the Tashan Circular Economy Park



Source: Bin (2010).

3.3. Technology Innovation

Datong Coal Mine has a technology innovation platform and an environment-monitoring and evaluation system. Key technologies used in the park include sets of high-efficient exploitation technologies; kaolin rock-deep processing technologies; water-saving energy conservation and emissions-reduction technologies, i.e. power plant cogeneration technology; kaolin rock heat-drying technology; coal gangue and kaolin rock-burning technology; low-temperature waste heat power-generation technology; etc.

For the treatment of sewage and industrial waste water, Tashan park combines different technologies according to water quality requirements and drainage directions instead of the traditional treatment methods of coagulation–settlement and coagulation–settlement filtration.

To deal with the depleted land, the park builds eco-restoration projects in the discarded areas. Mining activities produce three types of depleted land: the dump formed by accumulation of peeled surface soil and various solid waste in open-cut coal mining, the coal mine subsidence



land caused by the collapse of surface after coal mining, and the gangue dump accumulated by solid waste of coal gangue on surface along with coal mining. With the application of power-generation and waste-filling technology for comprehensive utilisation of coal gangue, existing and newly produced coal gangue are consumed at the annual rate of 5–20 percent.

3.4. Green Accounting and Flexible Management

Datong Coal Mine implements an internal green audit system that provides effective information for the enterprise's human and material resource adjustment and circular economy management, as well as favourable conditions for timely control of the resources market information. Also, the company has information-sharing platform in the park that can extract useful information based on the shared market, industry, and internal information to evaluate the status of circular economy and set development goals.

Datong Coal Mine has also established an ecological corporate culture that encourages its staff to instinctively protect the environment in their business activities and ensures that their own guidelines comply with the requirements of circular economy.

4. Outcomes and Impacts

Fundamentally, the Tashan industrial park has transformed the resource-based enterprise's traditional economic growth mode into sustainable development. With the establishment of the park, the environmental, social, and economic benefits have been demonstrated simultaneously.

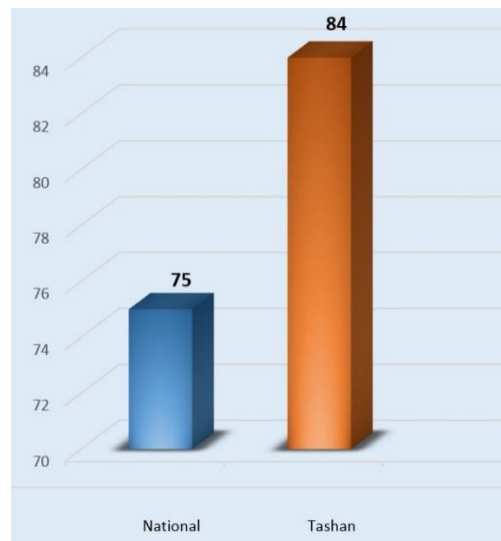
4.1. Economic, Environmental, and Social Impact of the Park

4.1.1. Economic benefits

As far as economic benefits are concerned, the Tashan industrial park has greater profitability. Based on its initial implementation scheme, the park may have an annual sales income of CNY6 billion, after-tax financial internal rate of return of 12.39 percent, return rate on investment of 10.57 percent, and profit and tax investment ratio of 14.78 percent. Although it may take 12 years to recoup the investment, this is still much better than the benchmark requirements of most construction projects.

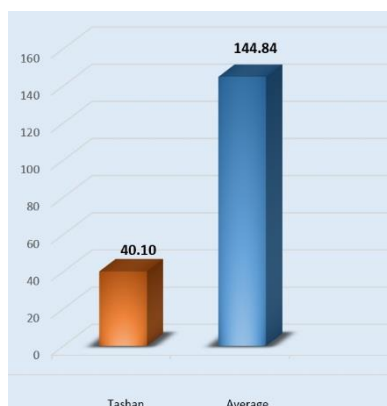


Figure 8.7. Resource Recycling Rate (%)



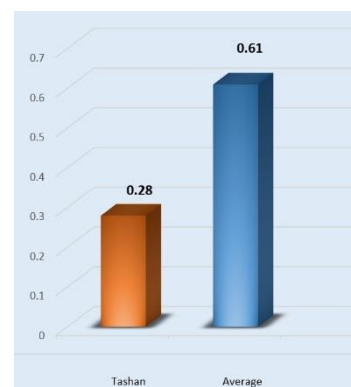
Source: Datong Coal Mine Group data.

Figure 8.8. Oil Consumption (t/a)



Source: Datong Coal Mine Group data.

Figure 8.9. Comprehensive Water Consumption ((t/a)



Source: Datong Coal Mine Group data.

4.1.2. Environmental benefits

With the increasing market demand and the expansion of the brickyard, the solid waste produced in the park, including coal gangue and pulverised fuel ash, can be reused. The domestic sewage and industrial waste water discharged into the sewage disposal plant can be recycled after treatment. With these, the park can achieve its goal of zero emission of waste water. Also, the company has built a garden-like new mining area that focuses on ecological vegetation, coal gangue treatment, and building of large-scale and full-range greenery projects.

**Table 8.1. Main Economic and Social Indicators in the Tashan Circular Economy Park**

Indicator	Unit	2010	2011	2012
Resource output indicator				
The main mineral resources output	CNY10,000 /tonne	0.346	0.415	0.429
Energy output	yuan/tonne of standard coal	0.969	1.123	1.181
Land output	CNY10,000 /ha	4,222.680	5,631.164	5,462.032
Water productivity	yuan/cubic metre	0.264	0.289	0.275
Resource consumption indicator				
Energy consumption per unit GDP	tonnes of standard coal/CNY10,000	1.032	0.891	0.847
Water withdrawals per unit GDP	cubic metres/CNY10,000	3.781	3.462	3.636
Energy consumption of mining plant	tonnes of standard coal/tonne	0.002	0.002	0.002
Water consumption of mining plant	cubic metre/tonne	0.125	0.145	0.138
Energy consumption of power plant	tonnes of standard coal/kWh	2.042	2.037	1.997
Water consumption of power plant	cubic metre/kWh	3.232	2.975	3.013
Comprehensive utilisation of resources				
Industrial solid waste comprehensive utilisation	%	4.701	4.941	5.918
Repeat utilisation rate of industrial water	%	59.564	55.513	55.621
Waste emissions target				
Industrial solid waste disposal	tonne	11,644,499	12,636,030	14,715,217
Industrial waste emissions	tonne	0	0	0
SO ₂ emissions	tonne	3,148.14	4,039.94	3,004.19
COD emissions	tonne	0	0	0

CNY = yuan, COD = chemical oxygen demand, GDP = gross domestic product, ha = hectare, kWh = kilowatt hour, SO₂ = sulphur dioxide.

Source: Datong Coal Mine Group data.

Table 8.2. Components of the Tashan Power Plant Smoke Emissions (volume fraction %)

N ₂	O ₂	CO ₂	SO ₂	NO ₂	CO	Dust
79	4.5	16.4	0.0046	0.0049	0.023	39.5 mg.m ³

CO = carbon monoxide, CO₂ = carbon dioxide, m³ = cubic metre, N₂ = nitrogen gas, NO₂ = nitrogen dioxide, O₂ = oxygen, SO₂ = sulphur dioxide.

Source: Datong Coal Mine Group data.



The Tashan Circular Economy Park's other achievements include:

- Thick coal seam extraction rate that is 9 percent higher than the national standard
- Associated resources utilisation rate of 95 percent; solid waste disposal efficiency of 100 percent
- Mine water reuse rate of 100 percent; implementation of a closed-circuit circulation system of industrial water
- Zero emission; zero discharge park COD pollutants as a whole
- Power plant-desulphurisation efficiency of more than 95 percent
- Dust-removal efficiency of 99.85 percent.

(1) Harmonious 'symbiosis' of social and natural environment

By fully implementing the 'reduce–reuse–recycle' principle and turning waste into treasure, the park has fundamentally improved the mining area's production environment and its surrounding natural environment. Moreover, the park has separated the production area from the living area. In 2014, the Datong Coal Mine Group started its plan of 'adding green, managing green, loving green' by planting more than 90,000 trees and 180,000 shrubs in the mining area. Its main purpose is to restore the ecological environment by strengthening the green management of residential and public spaces.

4.2. Impact on the Overall Industry and Regional Development

Ten years ago, Tashan was poor and desolate and with a very serious environmental problem. The park's construction has attracted many high-technology industries through investment, technology transfer, and product acquisition. Also, the park has made significant spillover effect on the surrounding areas such as rise in employment. In 2008, the local tax increased by about CNY1 billion.

The Tashan Circular Economy Park is the first successful pilot zone of circular economy in China's coal industry and is considered as representing the development direction of China's coal industry, energy industry, and resource-based enterprises.

With the success of Tashan, the Datong Coal Mine Group has developed ambitious plans for the development of circular economy, starting from 'point circular' to 'line circular', then to 'plane circular', and finally forming a three-dimensional network structure architecture of circular economy for sustainable development in the whole enterprise and region. After the experience of Tashan Circular Economy Park, four more circular economic parks have been listed in the plan: (i) Dongzhouyao–Maodaotou–Panjiayao Park, (ii) Xuangang Park, (iii) Shuonan Park, and (iv) Baijiagou Park.



Other domestic coal enterprises are also actively implementing the circular economy development strategy. In Shanxi, the Lu'an Mining Group has built four new eco-industrial parks in Tunliu, Gaohe, Lucheng, and Tengku. The Shanxi Xishan Coal and Electricity Group Co has constructed the Xishan Park Circular Economy Park. The practice of circular economy park has also expanded to other resource-based regions.

4.3. Obstacles Facing Circular Economy Initiatives

During the circular economy development process, the Datong Coal Mine Group encountered a lot of difficulties in project application, technology and finance, human resource management, etc.

4.3.1. Weak policy support on circular economy

A power plant is an important node in the implementation of circular economy in coal enterprises. However, due to national macro-control and industrial policies, project application and approval for its construction took a long time and encountered many difficulties. The same was true in other cases. Most countries overemphasise the role of large power plants while ignoring the environmental and social functions of small mining power plants in improving mining area environment and comprehensive utilisation of waste.

4.3.2. Financial barriers

Another stumbling block is the lack of financial support to a project's initial investment and infrastructure construction which are normally large and need a long period to develop the market. Relying on the enterprise alone to raise funds for the development of circular economy will often result in stagnation. Strong financial support at the start of a project is crucial.

4.3.3. Technology barriers

Compared with international circular economy parks and advanced domestic enterprises in the same industry, the technical level in China's circular economy parks still needs improvement as the state has not given enough support and encouragement to construct and develop circular economy in industrial parks. Most parks were constructed based on enterprises' own technology and development level.

4.3.4. Irrational human resource structure and outflow of special talents

The number of employees of the Datong Coal Mine Group is quite large. However, the professional technical and managerial personnel are extremely small, especially in the coal chemical industry, etc. Moreover, the relatively lower wages in midwest cities and their low attraction make it difficult for Datong Coal Mine to retain key talents, the outflow of which is becoming more and more serious. The comparative advantage of the company's present talents may gradually lose its position and turn into a disadvantage in the future.



5. Implications for Policy and Practice

Establishing new development models of circular eco-industrial park has great significance for developing countries as it solves the problem of shortage of mineral resources, resource waste, and environment pollution while raising resource utilisation ratio. The Datong Coal Mine Group Co, from an enterprise perspective, is a good example of how building circular economy parks can achieve green development. The Tashan mode can be called a mode of green sustainable development, equally emphasising resource extraction and resource conservation, and striving to improve resource utilisation rate, reduce waste emissions, and achieve zero pollution by means of clean production and resource recycling in a 'lateral coupling vertical closure' industry chain. The driving forces in the process are technology and system innovations. The Tashan case also shows that establishing a circular economy system is a complex and massive project that needs the support of national policy and funding, and also requires enterprises and society to improve awareness of the importance of developing circular economy.

5.1. Suggestions for Policymakers

The development of circular economy cannot be achieved without government support. Better regulations generally precede cleaner green practices. The most important thing in accelerating the transformation of economic development mode in China is to set up a policy support system in the development of circular economy. From the government perspective, a series of policies, regulations, standards, and management systems can be used to encourage enterprises to save energy, materials, and water and to use resources synthetically.

5.1.1. Policy differentiation for new and old enterprises

For example, in newly constructed mining areas, the government must improve market access standards, abandon traditional extensive development modes, and promote the concept of recycling economy to achieve win-win-win solution for the economy, society, and nature. In old mining areas, the government should pressure and support enterprises to improve their rates of resource recovery rate, coal washing, and resource recycling through green mining, clean production, and resource recycling.

5.1.2. Improving the circular policy system and legal system

The government can play a crucial role in supporting the development of circular economy by encouraging the recycling of resources, restraining resources-wasting behaviours, and stopping environmental pollution through various economic incentives and legal measures, including taxes, fees, financial credit encouragement system, environmental labelling system, commission system, etc.



5.1.3. Increasing capital support for circular economy enterprises

Other than preferential fiscal and industrial policies, the state can establish special development funds or increase subsidies for the construction of circular economy infrastructure such as energy, transportation, communications, network, water supply and drainage, and other infrastructure. Previous stages of R&D in circular economy have involved large investment and high risk. The state can establish a circular economy industry fund to support initial investment and stage of operation of circular economy. Furthermore, to remove barriers of private investment, government can provide financial guarantees or insurance normally through government-owned or -controlled corporations, central banks, ministries, or other government departments.

5.1.4. Establishing technology cooperation platform and knowledge-sharing platform

The state can set up national or provincial circular economy research centres and integrated technology cooperation platforms for enterprises, academia, and research organisations to enhance capability in key technology research, technology innovation, and market implication and promotion. The government can also help set up knowledge and information-sharing platforms to optimise investment environment and accelerate technology and experience-sharing in the development of circular economy.

5.1.5. Encouraging international cooperation and international technology transfer

The state can help regions and enterprises to widen the financing channel through international cooperation with international organisations such as the Asian Development Bank, World Bank, Asian Infrastructure Investment Bank, and other potential international sources with lots of green projects and professional and technical personnel training programmes. The government can further encourage joint ventures and foreign direct investments to promote technology transfer, both into and out of China. It is also necessary to strengthen international cooperation and build an advanced technology transfer platform for enterprises.

5.2. Suggestions for Practitioners

Chinese enterprises have a long way to go in circular economy development. The Datong Coal Mine Group's Tashan industrial park is a successful case from which resource-based enterprises can learn:

(1) Strategic orientation

To develop circular economy, the company must strive to extend the industry chain and increase the added value of products. It is necessary for an enterprise to formulate a strategy of circular economy and design a scientific plan and construct complete industry chain to achieve clean production and resource recycling. The design plan should be guided by the direction of national circular economy and should offer recycling solutions



to product obsolescence. Such effort would not only satisfy the government but also ensure the enterprise's competitiveness and the loyalty of employees.

(2) Technical transformation

Green technology and innovation are the key to achieve circular economy transformation. It is necessary to improve the level of technology and equipment. Enterprises should improve their investment in R&D and intensify inputs to the core technology of circular economy. Another way is to set up technology platforms to enhance communication with other enterprises, universities, and research institutes for key technology research. Furthermore, they can take advantage of advanced information network for rapid transmission of important information to improve communication and work efficiency among departments.

(3) Environmental governance and management innovation

Innovation helps an enterprise seize an opportunity and use it to introduce and create new ideas, processes, or products. The top management plays a crucial role in the process. Circular economy requires total innovation in the culture of the enterprise, i.e. arousing employees' awareness of environmental protection, energy saving, and knowledge and innovation. It is important for an enterprise to set up its green internal audit system to achieve environmental governance. The system covers monitoring, feedback and evaluation, rewards and punishments, and other detailed matters for implementation, and can help an enterprise set a reasonable goal of green development.

(4) Making a good human resource plan

Human resource planning is important to reduce cost and optimise the human resource of an enterprise. First, personnel structure should be optimised and operation skills of employees should be improved. Second, scientific planning should be made for career development through a promotions system to motivate employees to have a clear development direction and inspire work enthusiasm. Third, a performance-evaluation system should be perfected to harmonise the development goals of employees and enterprise and link their interests. Employees should be encouraged to have deeper understanding of theoretical and practical knowledge to lay a solid foundation for a knowledge- and technology-intensive human resource in the enterprise.



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