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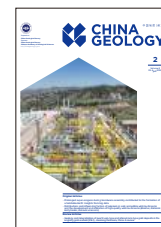
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News and Highlights

Rebirth of abandoned mines: A carbon emission industrial chain of “photovoltaic power generation-ecological restoration-land development-agricultural planting”

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1. Current status of abandoned mines in China

China is a major country in terms of mineral resources, with a long history of mineral resource exploitation and utilization. As a result, there is a large base of historically abandoned mines, presenting significant challenges for restoration and remediation. According to statistics from the National Mine Geological Environment Survey conducted by the China Geological Survey, as of 2018, there were approximately 99000 abandoned mines of various types in China. Categorized by mineral type, there were about 75000 non-metallic mines, 11700 metal mines, and 12300 energy mines. In terms of production scale, there were 2000 large-scale abandoned mines, 4200 medium-scale abandoned mines, and 92800 small-scale abandoned mines. By mining method, there were 80600 surface-mined abandoned mines, 16400 underground-mined abandoned mines, and 2000 abandoned mines utilizing other mixed mining methods.

2. Environmental hazards of abandoned mines in China

The primary ecological and environmental issues associated with abandoned mines include geological disasters, destruction of land resources, disruption of regional groundwater systems, and contamination of soil and water in mining areas. Among these, ground subsidence is the most significant ecological and environmental issue, particularly severe in abandoned coal mines. As of 2018, there were approximately 12000 ground subsidence incidents in abandoned mines nationwide, along with about 25000 sites with potential hazards of collapses, landslides, and debris

flows. In terms of impact severity, ground subsidence in mining areas affects large areas, causes heavy damage, and significantly impacts the livelihoods of local residents as well as industrial and agricultural production. The cumulative stockpile of solid waste from abandoned mines across the country amounts to approximately 49.6×10^9 t, with the total damaged land area exceeding 6300 km². Among these, non-metallic abandoned mines account for the largest area of damaged land.

3. Urgent need for abandoned mine remediation in China

Abandoned mines in China are numerous and widely distributed, with high restoration costs. Meanwhile, local financial resources are extremely limited, making it fundamentally impossible to meet the demands of ecological restoration. As a result, the ecological restoration of abandoned mines suffers from singular objectives, insufficient momentum, lack of vitality, and unsatisfactory outcomes, lacking both continuity and sustainability. Therefore, there is an urgent need to approach the ecological restoration of abandoned mines as a comprehensive and systematic project. This can be achieved by introducing relevant incentive policies to guide social capital participation, implanting and cultivating new industries, and developing industrial economy to consolidate restoration outcomes and achieve a virtuous cycle.

4. Photovoltaic power generation as a key technology and funding source for ecological remediation of abandoned mines

4.1. Case study of photovoltaic power generation in abandoned coal mines

Datong national advanced technology photovoltaic demonstration base in Shanxi Province: This is the China's first “Photovoltaic Leader” project and serves as a benchmark.

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The base was constructed in two phases, covering over 46.67 km² of coal mining subsidence areas distributed across three counties and districts of Yungang, Zuoyun, and Hunyuan counties. With a total installed capacity of 1.5×10^6 kW and a total investment of 11.12×10^9 Chinese yuan, the base generates approximately 1.5×10^9 kWh of electricity annually, supplying approximately 1 million households with annual electricity. It saves 4.8×10^5 t of standard coal and reduces carbon dioxide emissions by 1.28×10^6 t each year.

Huainan Panji coal mining subsidence area floating photovoltaic project in Anhui Province (“Solar PV on Water”): Once hailed as the “world’s largest floating photovoltaic power station”, this project utilizes water surfaces to construct a PV power station without occupying land resources. It employs floating technology, with photovoltaic modules installed on floating bodies. The total installed capacity reaches 1.5 GW, generating a substantial amount of electricity annually and effectively alleviating the pressure on the power grid in East China (Fig. 1).

Meishan town photovoltaic project in Changxing County, Huzhou, Zhejiang Province: This project serves as a case study of regional comprehensive remediation, making maximal use of abandoned mine pits. Floating photovoltaic stations were constructed on the water surfaces of abandoned mine pits, ground-mounted photovoltaic stations were built on the slopes of the mining area, and distributed photovoltaic stations were installed on the rooftops of abandoned factory buildings. By utilizing virtually all available space within the mining area, the project established a model of “power

generation on the pits, aquaculture beneath the pits.” It has transformed a previously “dirty, disorderly, and degraded” mining area into a modern town that integrates green energy, ecological agriculture, and industrial tourism—a vivid example of the concept that “lucid waters and lush mountains are invaluable assets.”

4.2. Case study of photovoltaic power generation in an abandoned metal mine

State power investment corporation’s Xinyu 100 MW integrated photovoltaic and energy storage power generation project at an abandoned gold mine in Fenyi Town, Xinyu City, Jiangxi Province: Covering an area of 3.14 km², this project delivers an annual electricity transmission of approximately 210×10^6 kWh, with an annual output value of 228×10^6 Chinese yuan. It saves 7.14×10^4 t of standard coal each year and contributes to the continuous improvement of the local ecological environment (Fig. 2).

Xintianling tungsten mine distributed photovoltaic project in Beihu District, Chenzhou City, Hunan Province: This project makes full use of idle spaces within the mining area to construct a distributed photovoltaic power generation facility. It encompasses 11 closed tailings ponds, abandoned factory buildings, a waste soil disposal site, and one rooftop area, covering a total area of approximately 0.36 km² with an installed capacity of 43 MW. The project is expected to generate over 40 million kWh of electricity annually, saving 11400 tons of standard coal and reducing carbon dioxide



Fig. 1. Huainan Panji coal mining subsidence area floating photovoltaic power station in Anhui (from www.cnenergy.org).

emissions by 3.43×10^4 t each year. It plays a significant role in optimizing the regional energy structure and alleviating the power supply pressure on Chenzhou's power grid (Fig. 3).

5. An integrated industrial chain of “photovoltaic power generation–ecological restoration–land development–agricultural planting”

In addressing the challenge of governing 99000 abandoned mines across the country, China has explored and developed a diversified, context-specific industrial chain that

integrates “photovoltaic power generation–ecological restoration–land development–agricultural planting.”

This approach has transformed the previously passive situation characterized by “financial investment, singular governance, and unsustainability.” By integrating the photovoltaic industry with ecological restoration and industrial cultivation, and leveraging the additional benefits of carbon reduction, abandoned mines have been converted from “ecological burdens” into “green assets.” This provides a new pathway for the transformation and development of resource-based regions globally.



Fig. 2. Abandoned gold mine in Fenxi Town, Xinyu City, repurposed as an integrated photovoltaic and energy storage power plant (from http://paper.people.com.cn/rmrb/html/2024-01/03/nbs.D110000renmrb_16.htm).



Fig. 3. Xintianling tungsten mine distributed photovoltaic project (from <https://solar.in-en.com/html/solar-2457916.shtml>).