From Coal to Roses

Innovative explorations for sustainable development in the abandoned mining area of Zichuan District, Shandong Province

Abstract: Zichuan District is a resource-depleted industrial city with a century-old coal mining history. Using the Dakuishan mine as a demonstration site, Zichuan District is pioneering an integrated “energy + industry” transition model that leverages decommissioned shafts and abandoned mines to develop a multifaceted complex comprising agrivoltaic power stations, distributed pumped storage power stations in abandoned shafts, mine-water waste heat recovery systems, and a high-end rose industry chain. Upon full completion, the project is expected to cut carbon dioxide (CO_2) emissions by 9,400 tons annually, restore 600 mu (approximately 40 hectares) of degraded mining land, generate over CNY 60 million in annual profit, and create 200 jobs. The initiative will promote integrated development of industries and form a virtuous cycle of “emissions reduction-resource utilization-efficiency improvement.” Amid the global trend of moving away from fossil fuels, this project can serve as a replicable model for green transition of other abandoned mining areas.

Keywords: Abandoned mines and disseminated shafts; renewable energy; rose industry value chain; ecological restoration; job creation

I. Background

Zichuan District of Zibo City, Shandong Province, is among the third batch of officially designated resource-depleted cities in China. The district is burdened with 195 decommissioned coal shafts and 64 abandoned mines. Mineral extraction has destroyed vegetation across 9,200 hectares, which entails high ecological restoration costs. The average groundwater level has dropped from 30 metres to below 200 metres. Additionally, widespread water rebound from abandoned mines has caused cross-layer contamination of underground high-quality aquifers. Centring on the coal-based economy, the district has fostered an energy-intensive and high-polluting industrial structure dominated by building materials and chemicals, with energy output efficiency reaching only about 70% of the provincial average.

Figure1. Overall project rendering
(Credit: Ecology Institute of Shandong Academy of Sciences)

II. Key Measures

(1) Building a Diversified and Synergistic Energy Network Using Mining Resources

The project leverages abandoned mines and decommissioned shafts to develop agrivoltaic power stations, distributed pumped storage power stations in mine shafts, mine-water waste heat pump systems, and associated infrastructure.

The project includes the following:

· The installation of a 2.6 MW photovoltaic system across more than 60 mu (approximately 4 hectares) of abandoned mining slopes, making efficient use of land resources to supply clean electricity to the park.

· A 100 kW experimental pumped storage station has been constructed, utilizing the 165-metre vertical drop of a disused shaft channel, marking China’s first pumped storage facility built in an abandoned mine.

· A 1.5 MW heat pump heating and cooling system has been installed to harness the stable 15°C temperature of mine water for cooling greenhouse facilities in summer and heating them in winter.

Figure 2. On-site view of the agrivoltaic power station in the park
(Credit: Ecology Institute of Shandong Academy of Sciences)

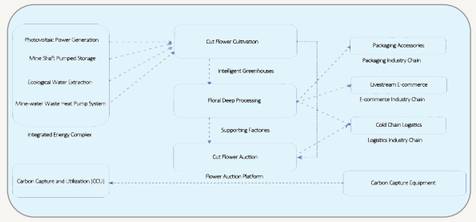
Figure 3. On-site view of the distributed pumped storage power station in an abandoned mine shaft
(Credit: Ecology Institute of Shandong Academy of Sciences)

(2) Driving Regional Economic Development via the Rose Industry Chain

· Capitalizing on the park’ s abundant land, clean electricity, waste heat, and mine water resources, the project has introduced a high-end rose fresh-cut flower industry through greenhouse cultivation.

· By supplying greenhouses with clean electricity generated on site, production costs can be reduced by 50%.

· With the rose industry as its foundation, the project is building a new economic ecosystem that integrates the secondary sector represented by floral deep processing with the tertiary sector, including e-commerce, logistics, livestreaming, and cultural tourism.



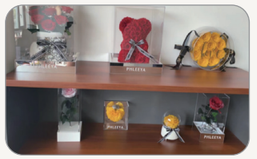


Figure 4. High-end rose industry chain
(Credit: Ecology Institute of Shandong Academy of Sciences)

(3) Advancing Ecological Restoration of Abandoned Mining Areas via Project Construction

· The project integrates agrivoltaic systems and flower cultivation to promote ecological restoration of former mines and aims to rehabilitate 200 mu (approximately 13.33 hectares) of abandoned land and 400 mu (approximately 26.67 hectares) of agricultural land.

· The project deploys an integrated water-fertilizer drip-irrigation system to supply water for flower cultivation while preventing long-term accumulation of mine water, thereby reducing the risk of infiltration and contamination of underground aquifers.

Figure 5. On-site view of mine ecological restoration and mine water treatment
(Credit: Ecology Institute of Shandong Academy of Sciences)

(4) Promoting Re-employment of Local Residents via Project Development

· The project operator has signed labour agreements with nearby communities to provide flower cultivation training and secure job placements for laid-off coal miners nearby.

· Phase I can address the re-employment of 30 individuals. Upon the full completion of Phase II, the project is expected to provide 200 re-employment opportunities annually.

Figure 6. On-site view of flower workers cutting roses
(Credit: Ecology Institute of Shandong Academy of Sciences)

III. Lessons Learned

The project has established a collaborative model involving government, enterprises, research institutions, and philanthropic organizations. Government agencies provided policy and institutional support and established a dedicated task force comprising various government departments to improve the efficiency of project approval. Research institutions provided a rational and science-based top-level design plan to avoid fragmented construction. Philanthropic organizations supported preliminary research and the dissemination of results. Financing institutions supplied stable funding, while developers and operators leveraged their technical expertise to ensure safe and steady project progress.

Case provided by CCICED Special Policy Study on Global Climate Governance and Green and Inclusive Transition