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Research on the Investment Mode and Path of China's Construction Waste Resourceization Industry

Lian Tan*

CCCC SHEC City Investment Development Co., Ltd., Wuhan 430056, Hubei Province, China

***Corresponding author:** Lian Tan, ouyakun@126.com

Abstract: At present, China's construction waste accounts for about 40% of the total municipal solid waste, with a large stock, a large increment, and a low rate of resource utilization, which is still a big gap compared with developed countries. However, the market prospect of the construction waste industry is relatively broad, the reuse value of the construction waste is high, so these resources should be fully utilized. This paper presents an in-depth analysis of projects in the construction waste resourceization industry, examining the industrial chain, development history, current status, investment and financing modes, and case studies. It proposes targeted strategies for companies to focus on the upstream and downstream segments of the construction industry's value chain and explores the implementation of investment opportunities in construction waste resourceization.

Keywords: Construction waste; Resourceization; Investment mode and path

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1. Overview of the construction waste industry

1.1. Definition and classification

Construction waste refers to the solid waste produced during construction, alteration, expansion, or demolition of buildings. It accounts for approximately 40% of municipal waste, making it the largest single category of solid waste produced by municipalities. Construction waste is characterized by its large volume, wide variety, and complex composition [1,2].

Construction waste can be divided into five categories according to the source: land excavation, road excavation, old building demolition, building construction, and building materials production waste [3].

1.2. Industry chain analysis

The upstream of the industrial chain deals with the demand side, including building units and construction enterprises, which mainly provide downstream enterprises with raw materials for construction waste as well as the removal and transportation of construction waste [4].

The middle reaches of the industry chain are equipment manufacturing enterprises, which mainly provide

product equipment and technical support for the downstream enterprises; the enterprises are small and scattered, the competition is fierce, and the degree of concentration is low.

The downstream of the industrial chain is the construction waste recycling and project operation enterprises, which are the core link of the whole industry, with obvious regionalization and low concentration.

1.3. Development history

The development history of construction waste resource utilization is mainly divided into three stages.

(1) Starting stage (1980–2007)

The construction waste recycling and treatment industry is primarily dominated by small enterprises or individual households. The transportation of construction waste across provinces and cities is relatively limited [5], demonstrating significant regional characteristics. The predominant method of treatment is landfill, indicating that the industry is still in its early stages of development.

(2) Rapid development stage (2008–2015)

In the past, a significant amount of construction waste was either disposed of arbitrarily or simply landfilled, resulting in wasted resources and environmental pollution. The 2008 earthquake heightened the demand for construction waste treatment, prompting the government to promote the large-scale utilization of construction waste resources. Consequently, the industry entered a high-speed development stage.

(3) Integration and optimization stage (2016–present)

The "Construction Waste Resource Utilization Industry Specification Conditions" strengthens the control over the construction waste recycling and treatment industry. This marks the transition of the industry from a dispersed and disorganized state into a phase of integration and optimization [6]. Consequently, the industry has begun to formalize, stabilize, standardize, and specialize in its development.

2. Construction waste industry status quo

2.1. Development status

The comprehensive utilization rate of construction waste in China is currently 13%, significantly lower than the over 70% utilization rate observed in developed countries. First-tier cities in China have higher rates than the national average, indicating substantial development potential.

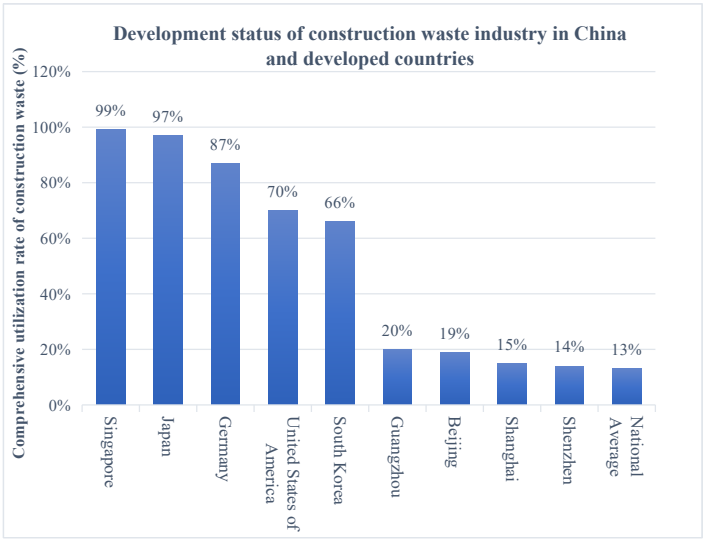

Figure 1. Development status of the construction waste industry in China and developed countries

2.2. Market prospects

The National Development and Reform Commission issued the "14th Five-Year Circular Economy Development Plan," which aims to increase China's construction waste utilization rate to 60% by 2025. The plan stipulates that the capacity for recycling construction waste needs to reach 250 million tons per year [7]. Therefore, during the "14th Five-Year Plan" period, there is more room for improving the utilization rate of construction waste [7].

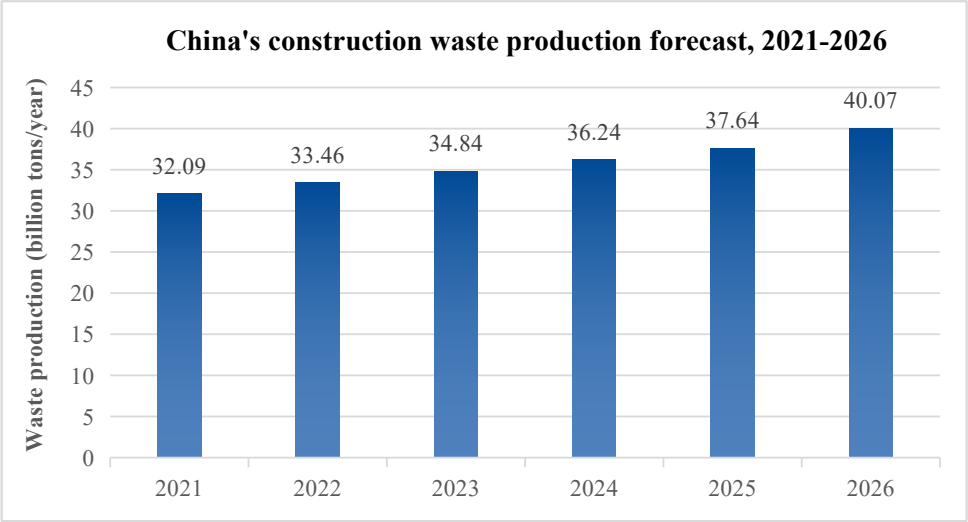

Figure 2. Forecast of China's construction waste production from 2021 to 2026

According to predictions, by 2026, the production of construction waste is expected to exceed 4 billion tons. Consequently, the market size for construction waste treatment is projected to surpass 140 billion yuan. This indicates that the construction waste market capacity remains relatively broad [7].

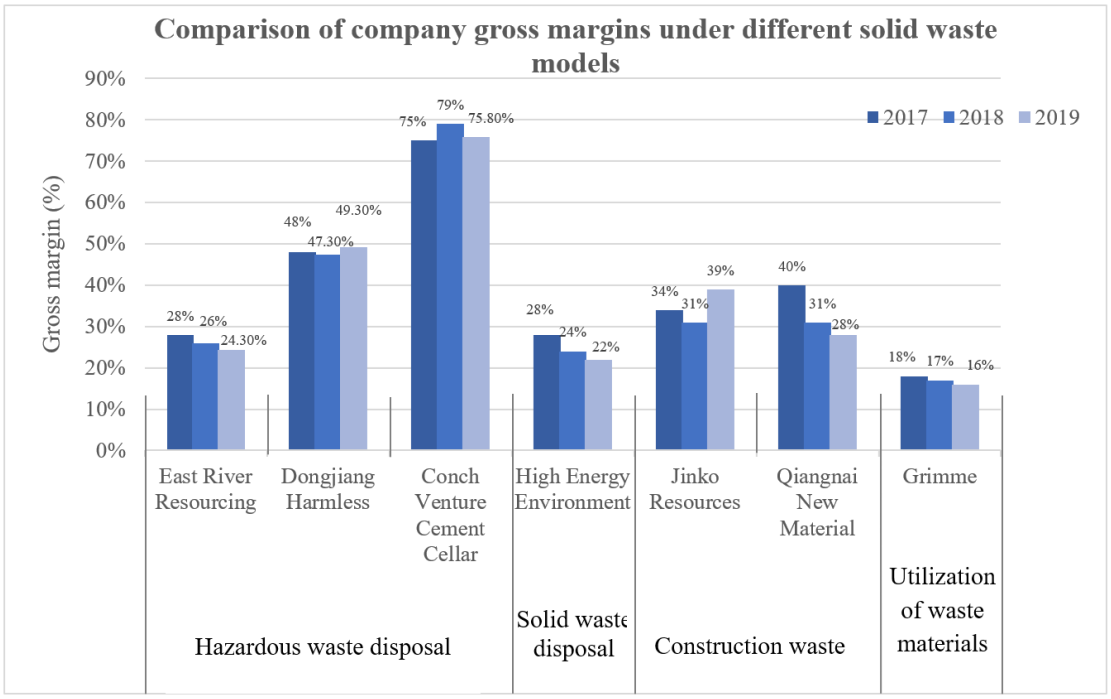

Figure 3. Comparison of company gross profit margins under different solid waste modes

The construction waste recycling industry demonstrates significant profitability within the solid waste sector, with gross profit margins ranging from 30% to 40% and net profit margins exceeding 10%. The increasing governmental focus on ecological environmental protection and the tightening restrictions on mountain stone mining have further amplified the industry's potential. Recycled aggregate, a product derived from construction waste, can partially substitute natural sand and gravel materials, presenting a valuable opportunity for development within the construction waste resource utilization industry.

2.3. Problems

Before delving into the pain points of the construction waste industry, it is essential to understand its revenue sources. Construction waste disposal enterprises primarily generate income from three main sources: payments from construction waste producers, revenue from the sale of products derived from construction waste resource utilization, and government subsidies for waste disposal [8]. These revenue streams correspond to three significant pain points within the industry.

2.3.1. Incoming materials: low quality and underfed

In practical market operations, construction waste resource treatment sites face two main pain points regarding incoming materials. The first is the issue of low quality in the materials received, and the second is the challenge of insufficient material volume [9].

(1) Low quality

Construction waste is mostly slag, gravel, etc., often mixed with domestic garbage or hazardous waste, which needs to be classified before further processing. Low-quality construction waste increases the operating costs of enterprises.

(2) Insufficient material

In 2021, Shenzhen City reported a capacity utilization rate of construction waste treatment of less than 40%, with other cities mostly experiencing even lower rates than Shenzhen [10]. This issue directly impacts the income of construction waste disposal enterprises.

2.3.2. Sales: lack of standards, lack of competitiveness

The market acceptance of recycled products derived from construction waste faces several challenges, primarily due to the immaturity of the product market and the absence of standardized regulations. China's demand for recycled products, such as recycled bricks, cement, and concrete, lacks uniform standards, hindering widespread acceptance. Additionally, recycled products often struggle to compete with conventional alternatives in pricing, posing challenges to their market penetration and sales.

2.3.3. Subsidies: weak and high policy risk

The policy risk associated with subsidy sources for construction waste resource utilization is considerable. Factors such as the COVID-19 pandemic, international dynamics, and overall economic conditions have heightened downward pressure on China's economy, making it increasingly challenging for local governments to allocate financial resources. In the current economic climate, with an emphasis on boosting domestic consumption and supporting industries like new energy and artificial intelligence, subsidies specifically allocated for construction waste resource utilization may face weakening or reduced priority.

In reality, apart from economically developed cities like Beijing and Shanghai, where subsidy policies are relatively robust due to better financial conditions, the majority of provinces and cities lack well-established subsidy policies specifically targeting construction waste resources. Many of these policies were released

before 2020 and have not been updated in recent years, with some subsidies even being discontinued. This lack of consistent support places additional pressure on construction waste resource projects to sustain themselves amidst uncertain financial circumstances.

2.4. Own advantages

The construction waste industry presents high barriers, and the company currently lacks the necessary qualifications, performance records, and expertise in this sector. However, the investment arm of the Second Aviation Bureau has amassed nearly two decades of experience in investment business, cultivating certain comparative advantages. These include a complete industrial chain within the construction industry, a strong credit platform as a central government enterprise, ample financial resources, and support for transformation initiatives. These factors provide a solid foundation for the company to venture into construction waste resourceization.

3. Typical models and cases

The main investment and financing modes of existing construction waste treatment projects include Public-Private Partnership (PPP) mode, enterprise investment + government purchasing service mode, and Engineering, Procurement, Construction, and Operation (EPC+O) mode.

3.1. PPP mode: Beijing Chaoyang District Construction Waste Resource Utilization Center PPP Project

3.1.1. Project introduction

The project is situated in the northwest area of Chaoyang District Circular Economy Industrial Park, covering approximately 320 acres of land. It is designed to handle an annual capacity of 1.23 million tons and encompasses a construction waste treatment system, incineration slag treatment system, resource-based product production system, and supporting facilities. The project will utilize a combination of fixed in-plant and out-of-plant mobile treatment facilities. The total investment for the project is estimated to be 250 million yuan [11]. With a concession period of 15 years, it marks the inaugural in-situ disposal project for demolition waste at a shanty reform site in China.

3.1.2. Project mode

The project operates under the Build-Operate-Transfer (BOT) mode, where Beijing Construction Engineering and Capital Environment jointly form a consortium, contributing 90% of the project's social capital as the social capital party. This consortium, along with contributors from the Chaoyang District government, establishes a project company. The project company assumes responsibility for investment, financing, construction, and operation and maintenance during the concession period. It generates revenue through product sales from resource utilization, fees from waste incineration enterprises for slag disposal, and construction waste disposal fees throughout the concession period [12].

3.1.3. Project operation

Operated by the resource company under Beijing Construction Engineering, this project boasts an impressive track record, having executed over 30 projects with an annual disposal capacity of 19 million tons [13]. With such extensive experience in the construction waste disposal industry, the project is well-equipped to handle up to 1 million tons of construction waste annually, achieving an impressive resource utilization rate of 95%. This

capability has garnered recognition from leaders at all levels. Moreover, the recycled products from this project find wide applications in municipal roads, landscape gardening, and pavement paving in Chaoyang District, yielding commendable operational outcomes.

3.1.4. Project inspiration

How does this project break through the three major dilemmas of construction waste resource utilization?

(1) Feeding problem

In 2021 alone, Beijing produced over 147 million tons of construction waste, with an annual growth rate of 15%. To manage this significant volume, the disposal process can be coordinated across districts based on the production and treatment of construction waste, ensuring that the project has a steady stream of waste to treat directly from the source [13].

(2) Sales problem

As per the "Beijing Construction Waste Classification and Consumption Management Measures (Interim)," municipal government-invested construction projects like municipal, transportation, landscaping, and waterworks must ensure that at least 10% of designated project parts utilize recycled construction waste products [14]. Currently, these recycled products find application in municipal roads, landscaping, pedestrian walkways, and river training. Moreover, Beijing has introduced the "On-Site Resource Utilization of Construction Waste Comprehensive Utilization of Recycled Products Information Platform," facilitating seamless connection between suppliers and buyers for efficient procurement and utilization.

(3) Subsidies

The project's income from construction waste disposal amounts to RMB 52.4 per ton, with RMB 30 contributed by waste-generating units and RMB 22.4 subsidized by the government [14]. This revenue adequately covers the treatment cost, enabling the enterprise to achieve sustainable development even with minimal profits.

Furthermore, Beijing Construction Engineering Resources Company has introduced an "integration mode of decoration waste collection, transportation, and disposal," offering end-to-end services from waste collection to disposal. This approach effectively addresses challenges related to supervision, transportation, and disposal, ensuring orderly collection, standardized disposal, and comprehensive supervision [15].

The project's key strength lies in its geographical advantage, making it non-replicable. Leveraging the PPP mode, the company can manage both the construction and operation aspects of the project, ensuring high overall standardization suitable for larger-scale projects. However, constraints imposed by the 10% general public budget limit the project's current scope. As a result, careful consideration of the project area and conditions is necessary to maximize its potential impact.

3.2. Investment promotion + government purchase service mode: Huangshi Yangxin County Construction Waste and Bulky Waste Resource Disposal Center Project

3.2.1. Project introduction

The project encompasses approximately 100 acres of land, incorporating essential facilities such as production plants, warehouses, power distribution rooms, staff dormitories, and restaurants. Supporting infrastructure like plant roads, landscaping, water supply and drainage, power distribution, and fire safety measures will also be constructed. The production setup includes equipment such as jaw crushers, feeders, impact crushers, vibrating screens, and corresponding environmental protection facilities [16]. The planned construction period is 12

months, with a total investment of approximately 84.93 million yuan. The project's operational duration spans 9 years, divided into three phases of 3 years each.

3.2.2. Project mode

The "investment + government purchase service" model is executed in two distinct stages. The initial stage involves investment, during which the government identifies 3–5 qualified social capitalists through an investment selection process. These entities must demonstrate the capacity to fulfill the project's investment requirements and agree to obtain returns through government-purchased services. At this stage, no Investment Cooperation Agreement is signed. Emphasis is placed on evaluating the technical and construction proposals, formation plans for the project company, investment strategies, and past performance of potential investors. The subsequent stage involves government-purchased services. The project is included in the Hubei provincial government's service catalog for sewage and waste treatment services, avoiding the restrictions of procurement works and aligning with government procurement service regulations. The government ultimately selects one social capitalist from the previously identified pool of 3-5 potential candidates. The chosen entity establishes a project company responsible for investment, construction, operation, and maintenance. An Investment Cooperation Agreement is signed between the winning bidder and the government, followed by a Waste Disposal Service Agreement between the project company and the government (typically lasting 3 years) [17]. The project company holds the option to renew the Waste Disposal Service Agreement before each term expires during the Investment Cooperation Agreement period. Upon the conclusion of the Investment Cooperation Agreement, the government may choose to renew it with the social capitalist. This phase focuses on evaluating the operational and maintenance plans, environmental protection measures, sales strategies for resource-based products, and service fee proposals offered by potential social capitalists.

3.2.3. Project boundary conditions

(1) The project's land use rights are leased, and the assets resulting from project investments are owned by the successful social capitalist or its project company.

(2) The project's return mechanism involves the government making annual payments to the successful social capitalist/project company for the purchase of waste disposal services, ensuring a minimum level of service usage.

(3) The project company is fully funded by social capital and establishes mechanisms for price adjustments and performance evaluations during the operational period. The payment of waste disposal service fees is tied to the results of performance appraisals [17].

(4) The project was awarded to Yangxin Xinyuan Hydropower Construction Company, a local state-owned engineering company in Yangxin County, with a winning bid that includes a downward fluctuation rate of 2.04%.

3.2.4. Project revelation

This model, characterized by pure enterprise investment in project investment and construction, entails greater risks. However, through the government's purchase of service agreements spanning three years, the project can benefit from flexible price adjustments. Moreover, by allocating a portion of the budget to the project, better standardization can be achieved, rendering this model suitable for smaller projects in counties. To enhance project financing, it is essential to assess project conditions carefully, ensuring reasonable measurement of treatment prices and guaranteed volume. Additionally, leveraging fixed assets mortgage and pledging accounts receivable can effectively address funding challenges.

3.3. EPC + O mode: Ziyang City, Sichuan EPC + O Project of Urban Solid Waste Resource Utilization and Recycling Comprehensive Disposal

3.3.1. Project introduction

The total investment for the project amounts to approximately 320 million yuan, with a construction duration of 2 years and an operational period spanning 28 years. The project aims to handle an annual scale of 1.3 million tons of construction waste and 50 tons per day of bulky waste. Project components encompass civil engineering for functional areas, construction and decoration, procurement and installation of facilities and equipment, general leveling, supporting ancillary works, and connecting roads. The owner bidder is Ziyang City Investment Municipal Services Co., Ltd., with self-financing from the enterprise as the funding source. Project revenue primarily derives from resource utilization, totaling about 3.5 billion yuan, representing 84% of total revenue, while waste treatment service fees contribute approximately 660 million yuan, accounting for 16%. Although the project benefits from guaranteed garbage sources and waste treatment service fees, it faces the risk associated with the marketable sales of resourceized products. Having completed preliminary project work, feasibility studies, and approvals, the project has opted for the EPC + O model and is progressing with bidding processes. The next steps involve recommending cooperation programs to Ziyang City Investment and inviting CCCC and solid waste operation units to participate in cooperation arrangements as appropriate.

3.3.2. Project revelation

This project model is uncomplicated and can drive the primary business. Typically, the owner is predominantly a platform company, which involves relatively higher risks and is suitable for small and medium-sized projects. Prioritizing project areas and conditions, along with establishing binding consortium partnerships, is crucial to mitigate risks and ensure project success [18].

4. Suggestions for the company's investment in the construction waste industry

4.1. Excellent mode

(1) Effective synergy between the company's main responsibilities and the promotion of construction waste resource utilization business should be fostered, aligning with urban renewal and district development initiatives.

(2) Collaboration with ongoing assembly building and housing projects should be leveraged to bolster the market path for recycled products, facilitating mutual growth. (3) Priority will be given to engagement with new mechanisms and adjustments in PPP policies, with a preference for BOT mode and government purchase services compliant with financial budget allocations. Additionally, active participation in industry standard development as the leading entity is recommended.

4.2. Selection of projects

(1) Region selection

Market demand guides the choice, with a preference for regions with significant construction waste production, clear subsidy policies, and developed infrastructure. Priority areas include major construction hubs like the Yangtze River Economic Zone, Yangtze River Delta, Pearl River Delta, and Chengdu-Chongqing metropolitan area, especially those aligned with Group and Second Aviation Bureau project concentrations.

(2) Mode selection

Project waste disposal pricing and guaranteed volume should be set to optimize investment returns,

with careful consideration of financing packages to minimize own capital contribution. Mechanisms for exit and adjustment should be scientifically devised. The unit price for purchased services should comprehensively account for investment amortization, operational expenses, product sales, and other factors.

(3) Selection of partners

Thorough due diligence is essential, with a preference for leading enterprises in the environmental protection industry, boasting core technical expertise and proven operational track records.

(4) Selection of products

Technological advancements should be pursued to elevate the quality and value-added attributes of recycled products, such as recycled cement and asphalt.

4.3. Strong capability

(1) Research capacity enhancement

Research local subsidies, policies on recycled product utilization, existing project models, local competition dynamics, and project owners extensively. Preferably, select regions and projects based on this research.

(2) Talent training reinforcement

Intensify internal training efforts and external talent recruitment to enhance market development, evaluation, judgment, project construction, and operation capabilities. Increase training exchanges to elevate overall proficiency levels.

(3) School-enterprise collaboration strengthening

Facilitate collaboration between schools and enterprises to address key technical challenges. Utilize the abundant resources and significant demand from the Second Aviation Bureau to drive the industrialization of cutting-edge technologies, enhance product quality, reduce production costs, and attain a competitive edge in the market.

Disclosure statement

The authors declare no conflict of interest.

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