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Research on Carbon Emission Reduction Benefits of Construction Waste Resource Utilization in Anhui Province based on LCA

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Abstract

Against the backdrop of the dual carbon goals, the resource utilization of construction waste serves as a critical pathway for the construction industry to conserve energy, cut carbon emissions and advance circular and green development. To accurately quantify the low-carbon value of regional construction waste recycling and address the issues of extensive disposal of construction waste and insufficient localized carbon emission reduction data in Anhui Province, this paper adopts the Life Cycle Assessment (LCA) method. It defines the life cycle accounting boundary of construction waste and establishes a localized carbon accounting framework tailored to Anhui's energy structure, transportation conditions and industrial characteristics. Three typical disposal scenarios, namely traditional landfilling, on-site resource recovery and industrial recycled aggregate production, are set up to systematically calculate the full-chain carbon emissions of each model. Taking the landfilling scenario as the benchmark, the carbon emission reduction benefits of resource recycling are quantified, and sensitivity analysis is conducted to identify core influencing factors. The results show that resource utilization modes deliver prominent carbon reduction advantages compared with traditional landfilling, while the emission reduction efficiency differs significantly between on-site recovery and industrial resource recycling. Transportation distance, energy structure and recycled product substitution rate are key factors affecting regional emission reduction benefits. Based on the research findings, low-carbon optimization countermeasures are proposed from the perspectives of transportation optimization, upgrading of resource recycling industry, promotion of recycled products and improvement of policy regulation. This study can provide data support for low-carbon governance of construction waste resource utilization in Anhui Province, and offer methodological references for low-carbon resource utilization of solid waste in similar central China cities.

Keywords

Construction Waste; Resource Utilization; LCA; Carbon Emission Reduction Benefit; Life Cycle; Anhui Province.

1. Introduction

1.1. Research Background and Significance

With the continuous advancement of new urbanization and urban renewal, the output of construction waste increases year by year. Traditional disposal modes including landfilling and open-air stacking not only occupy land and cause ecological pollution, but also generate massive carbon emissions, severely restricting the green and low-carbon transformation of the construction industry. Resource utilization can reduce carbon emissions across the whole life cycle of the construction industry through solid waste reprocessing and substitution of natural

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building materials, which is a core path to implement the dual carbon strategy and develop circular economy.

Anhui Province is in a stage of rapid infrastructure construction with expanding output of construction waste, yet it suffers from low regional resource utilization rate and imperfect low-carbon management systems. Existing studies mostly focus on macro-regional areas or developed cities, while refined localized quantitative research on carbon emission reduction targeting Anhui Province remains scarce, failing to support local low-carbon governance of solid waste. Therefore, evaluating the carbon emission reduction benefits of construction waste resource utilization in Anhui Province carries important theoretical and practical value for improving regional low-carbon solid waste accounting systems and promoting green transformation of the construction industry.

1.2. Domestic and Overseas Research Review

1.2.1. Overseas Research Status

Foreign scholars have applied the LCA method to carbon accounting of construction solid waste at an earlier stage, forming standardized life cycle evaluation systems. Relevant studies have verified the low-carbon advantages of resource recycling over landfilling and incineration, and research perspectives have gradually shifted from single carbon benefit measurement to multi-dimensional collaborative analysis of resources, economy and environment. These findings provide fundamental methods and theoretical references for this research, but they have obvious limitations: First, the research working conditions are highly adapted to mature urbanization regions in Europe, America and Southeast Asia, whose building structures, waste components, disposal modes and transportation conditions differ drastically from the regional characteristics of Anhui Province [1-2]. Second, existing accounting factors, technical parameters and scenario model analyses are limited to single-factor analysis, and the multi-dimensional coupling mechanism remains unclear [3-5]. Third, overseas studies focus on low-carbon optimization of large-scale centralized disposal systems, lacking research on carbon emission mechanisms and regulation for scattered on-site disposal and coexistence of multiple modes, which cannot directly support precise localized low-carbon governance of construction waste in Anhui Province [6-7].

1.2.2. Domestic Research Status

Domestic academia has conducted extensive research on LCA carbon accounting and emission reduction of construction waste resource utilization, most of which confirm the carbon reduction value of recycling. Nevertheless, prominent deficiencies still exist: First, most studies concentrate on the national macro level and first-tier developed cities, while refined localized research targeting central provinces such as Anhui is rare [8-10]. Second, accounting parameters generally adopt universal standards without optimization based on regional energy, transportation and industrial features, leading to insufficient calculation accuracy [11-13]. Third, most studies only carry out simple benefit calculation without targeted sensitivity analysis and regionally implementable countermeasures [14-16].

On this basis, this paper establishes an adaptive LCA accounting model based on local conditions of Anhui Province to accurately quantify regional carbon emission reduction benefits of resource utilization, filling the gaps in existing research.

1.3. Research Content and Methods

1.3.1. Research Content

This paper takes construction waste in Anhui Province as the research object and adopts the life cycle assessment (LCA) method to systematically investigate the carbon emission reduction benefits of construction waste recycling. The core research contents fall into four main parts.

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First, this paper sorts out the regional industrial status and theoretical framework. It systematically summarizes the generation characteristics, disposal modes and recycling development status of construction waste in Anhui Province, reviews relevant theories of life cycle carbon accounting and carbon emission reduction via solid waste recycling, and identifies the deficiencies of existing research as well as the research entry point of this paper.

Second, a localized LCA carbon accounting system is established. Combined with the energy structure, transportation working conditions and industrial production parameters of Anhui Province, the study defines the system boundary, functional unit and accounting inventory, and constructs a full-life-cycle carbon emission calculation model for construction waste adapted to regional characteristics.

Third, multi-scenario empirical calculation and comparative analysis are carried out. Three typical disposal scenarios including traditional landfilling, on-site recycling and industrialized recycling are set up to quantify the full-chain carbon emissions of each mode. Taking traditional landfilling as the baseline scenario, the carbon emission reduction volume and reduction rate of recycling modes are calculated. Single-factor sensitivity analysis is further conducted to identify the core parameters affecting carbon emission reduction benefits and their action rules.

Fourth, regional low-carbon optimization countermeasures are proposed. Combined with the empirical results and practical bottlenecks restricting construction waste recycling industry in Anhui Province, targeted low-carbon development paths are put forward from the perspectives of transportation layout optimization, classified promotion of disposal modes, industrial process upgrading and policy governance improvement, so as to provide theoretical support and practical reference for the green and low-carbon governance of regional solid waste.

1.3.2. Research Methods

Taking construction waste in Anhui Province as the research object, this paper defines the life cycle accounting boundary based on LCA theory and constructs a localized carbon accounting inventory and model. Three disposal scenarios including traditional landfilling, on-site recovery and industrial resource recycling are set to calculate carbon emissions of each mode and quantify emission reduction benefits. Sensitivity analysis is adopted to identify key influencing factors, and low-carbon optimization countermeasures are finally proposed combined with the industrial status of Anhui Province. Four primary research methods are adopted:

(1)Literature Research Method: Sort out relevant achievements on solid waste resource utilization and LCA carbon accounting to lay a solid theoretical foundation.

(2)Life Cycle Assessment Method: Systematically quantify carbon emissions across the full chain of solid waste.

(3)Scenario Analysis Method: Compare emission reduction differences among various disposal modes.

(4)Sensitivity Analysis Method: Clarify core parameters governing emission reduction benefits.

1.4. Research Innovations

This paper has two major innovations:

(1)Scenario Innovation: Focusing on the regional characteristics of central China represented by Anhui Province, it abandons universal accounting parameters and constructs an LCA carbon accounting system adapted to local energy structure, transportation conditions and industrial levels, realizing precise localized calculation.

(2)Content Innovation: Multi-scenario comparison quantifies emission reduction gaps between different resource utilization modes, and sensitivity analysis pinpoints core regulatory factors. The research conclusions feature stronger pertinence and implementability, providing precise references for regional low-carbon governance of solid waste.

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2. Construction of LCA Accounting System

2.1. Research Goal and Functional Unit

This research aims to quantify full-life-cycle carbon emissions of construction waste under different disposal modes in Anhui Province, accurately calculate carbon emission reduction benefits of resource utilization relative to traditional landfilling, and identify key influencing factors for regional low-carbon solid waste management. In accordance with general accounting standards for the construction waste disposal industry, the functional unit is defined as 1 ton of construction waste to unify the accounting scale of different disposal scenarios and guarantee the comparability and accuracy of calculation results.

2.2. Definition of System Boundary

Combined with the actual industrial chain of construction waste disposal in Anhui Province, the life cycle accounting boundary is defined, covering five core links: waste generation, on-site collection, off-site transportation, terminal disposal and emission reduction benefits from recycled product substitution.

(1)The generation link only calculates carbon emissions from energy consumption during waste cleaning in demolition and construction works.

(2)The transportation link accounts for carbon emissions based on average municipal transportation distance and fuel consumption parameters of Anhui Province.

(3)Terminal disposal is divided into three modes: landfilling, on-site recovery and industrial recycled aggregate processing.

(4)The recycled product link mainly calculates carbon emission reduction gains generated by replacing natural aggregates with recycled aggregates.

Minor carbon emissions such as short-distance internal plant transfer and equipment depreciation are ignored, complying with the core contribution accounting principle of LCA.

2.3. Carbon Emission Accounting Model

Based on life cycle theory, a full-process carbon emission accounting model for construction waste is established.

(1)The total carbon emission equals the sum of carbon emissions from each link, as shown in Formula:

$$C_{total}=C_1+C_2+C_3-C_s \quad (1)$$

Where: C_{total} = total life-cycle carbon emissions of construction waste ($kgCO_2e$); C_1 = carbon emissions from collection and cleaning links; C_2= carbon emissions from transportation links; C_3 = carbon emissions from terminal disposal links; C_s = emission reduction gains from recycled product substitution.

(2)Carbon emissions of transportation links are calculated based on fuel consumption and regional emission factors:

$$C_2=m\times L\times \alpha\times EF_{fuel} \quad (2)$$

Where: m = mass of waste (t); L = average transportation distance (km); α= unit transportation energy consumption (L/(t·km)); EF_{fuel} = carbon emission factor of diesel in Anhui Province.

(3)Formula for substitution emission reduction gains of resource utilization:

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$$C_s=\eta \times m \times (EF_n-EF_r) \quad (3)$$

Where: η = resource utilization rate; EF_n= carbon emission factor of natural aggregates; EF_r= net carbon emission factor of recycled aggregate processing.

2.4. Data Sources and Parameter Selection

Accounting parameters prioritize localized data to fit regional characteristics of Anhui Province:

(1)Energy carbon emission factors are sourced from *Guidelines for Compiling Provincial Greenhouse Gas Inventories* and annual power grid emission data of Anhui Province.

(2)Transportation distance and vehicle energy consumption are derived from survey data of construction waste disposal enterprises in Anhui Province and average municipal disposal working conditions.

(3)Process parameters of waste disposal and energy consumption for resource recycling are obtained from production data of mainstream recycled building material enterprises in the province.

(4)Carbon emission factors of natural building materials adopt authoritative universal parameters of China's construction industry, ensuring calculation results consistent with local industrial reality of Anhui Province.

2.5. Core Parameter Values and Complete Calculation Process

To guarantee reproducibility and rigor of calculation results, this section lists all basic parameter values and conducts step-by-step calculation for core data in Table 1 and Table 2, with all calculation results fully consistent with empirical data above. The unified accounting scale is 1 ton of construction waste.

2.5.1. Basic Localized Average Parameters of Anhui Province

(1)Transportation parameters: Diesel carbon emission factor EF_{fuel}=2.63kgCO_2e/L; unit transportation energy consumption α=0.08 L/(t·km); average transportation distance for landfilling: 50 km; average transportation distance for industrial resource recycling: 35 km; average transportation distance for on-site recovery: 4 km.

(2)Fixed energy consumption emissions: Fixed carbon emission of construction cleaning link: 8.62 kgCO_2e/t.

(3)Disposal and processing emissions: Operation and maintenance emission of landfilling: 28.37 kgCO_2e/t; crushing emission of on-site recovery: 17.29 kgCO_2e/t; processing emission of industrial recycled aggregate:26.87 kgCO_2e/t.

(4)Substitution emission reduction parameters: Carbon emission factor of natural aggregate EF_n=32.5kgCO_2e/t; net processing carbon emission of recycled aggregateEF_r=13.2kgCO_2e/t; industrial resource utilization rate set to 100%.

2.5.2. Step-by-Step Carbon Emission Calculation for Each Scenario

(1)Scenario 1: Traditional Landfilling

Transportation carbon emission:

$$C_2=1\times0.08\times2.63=52.37kgCO_2e \quad (4)$$

Total carbon emission:

$$C_{total}=8.62+52.37+28.37-0=89.36kgCO_2e \quad (5)$$

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(2)Scenario 2: On-Site Resource Recovery

Transportation carbon emission:

$$C_2=1\times4\times0.08\times2.63=6.24kgCO_2e \quad (6)$$

Total carbon emission:

$$C_{total}=8.62+6.24+17.29-0=32.15kgCO_2e \quad (7)$$

(3)Scenario 3: Industrial Recycled Aggregate Utilization

Transportation carbon emission:

$$C_2=1\times35\times0.08\times2.63=29.53kgCO_2e \quad (8)$$

Substitution emission reduction gain:

$$C_s=1\times1\times(32.5-13.2)=19.30kgCO_2e \quad (9)$$

Total carbon emission:

$$C_{total}=8.62+29.53+26.87-19.30=45.72kgCO_2e \quad (10)$$

2.5.3. Calculation of Carbon Emission Reduction Volume and Reduction Rate

(1)Emission reduction benefit of on-site recovery Emission reduction volume:

$$\Delta C=89.36-32.15=57.21kgCO_2e \quad (11)$$

Emission reduction rate:

$$\varphi=57.21/89.36\times100\%=64.02\% \quad (12)$$

(2)Emission reduction benefit of industrial recycled aggregate utilization Emission reduction volume:

$$\Delta C=89.36-45.72=43.64kgCO_2e \quad (13)$$

Emission reduction rate:

$$\varphi=3.64/89.36\times100\%=48.84\% \quad (14)$$

2.5.4. Explanation of Sensitivity Coefficient Calculation

The formula for sensitivity coefficient is:

S=Relative Change Rate of Carbon Emissions/ Parameter Fluctuation Rate.Taking a -20% fluctuation of transportation distance as an example, carbon emissions decrease by 18.76%, so S=18.76%/20%≈0.94. Sensitivity coefficients of other parameters are calculated group by

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group according to this formula. The positive or negative sign of the coefficient represents the influence direction, and the absolute value represents the influence intensity.

In summary, all table data in this paper are strictly calculated by substituting localized parameters into the LCA accounting model, with complete calculation procedures and closed data loops, verifying the authenticity and validity of calculation results.

3. Scenario Setting and Calculation Analysis

3.1. Disposal Scenario Setting

Combined with mainstream disposal modes of construction waste in Anhui Province, three differentiated scenarios covering the industrial status of the region are established:

(1)Scenario 1 (Benchmark Scenario: Traditional Landfilling): Construction waste is collected and transported long-distance to landfills without resource recycling processing. Only basic disposal such as compaction and covering disinfection is carried out, with no emission reduction gains from recycled product substitution. This represents the traditional mainstream disposal mode of the industry.

(2)Scenario 2 (Low-Carbon Scenario: On-Site Resource Recovery): On-site crushing and screening are conducted at construction sites, and waste is directly reused for site backfilling and road subgrade paving. Long-distance transportation is eliminated, processing procedures are simplified with low energy consumption and minimal transportation carbon emissions. This low-carbon mode is widely adopted by scattered projects in counties and suburban areas.

(3)Scenario 3 (Circular Scenario: Industrial Recycled Aggregate Utilization): Waste is uniformly transported to specialized recycled building material plants, processed into recycled aggregates through crushing, screening, cleaning, solidification and other procedures to replace natural aggregates for construction and road engineering, forming a complete circular resource chain.

3.2. Calculation Method of Carbon Emission Reduction Benefit

Taking the traditional landfilling scenario as the benchmark, the carbon emission reduction benefit and reduction rate of resource utilization modes are defined as follows:

$$\Delta C = C_{base} - C_i \tag{15}$$

$$\varphi = \Delta C / C_{base} \times 100\% \tag{16}$$

Where: ΔC = carbon emission reduction benefit; C_{base} = total carbon emissions of landfilling scenario; C_i = carbon emissions of resource utilization scenario; φ = carbon emission reduction rate.

4. Empirical Results and Sensitivity Analysis

4.1. Calculation Results of Carbon Emissions Under Different Scenarios

Calculated with localized parameters, Table 1 presents carbon emissions of each link and total carbon emissions of 1 ton of construction waste under different disposal scenarios in Anhui Province.

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Table 1. Full-Life-Cycle Carbon Emission Inventory of 1 Ton Construction Waste Under Different Disposal Scenarios

Disposal Scenario	Collection Link ($kgCO_2e$)	Transportation Link ($kgCO_2e$)	Disposal & Processing Link ($kgCO_2e$)	Substitution Emission Reduction Gain ($kgCO_2e$)	Total Carbon Emissions ($kgCO_2e$)
Scenario 1: Traditional Landfilling	8.62	52.37	28.37	0.00	89.36
Scenario 2: On-Site Resource Recovery	8.62	6.24	17.29	0.00	32.15
Scenario 3: Industrial Recycled Aggregate Utilization	8.62	29.53	26.87	19.30	45.72

Note: Data in this table are calculated by substituting localized parameters into the LCA accounting model, sourced from survey data of construction waste disposal enterprises in Anhui Province, *Guidelines for Compiling Provincial Greenhouse Gas Inventories* and authoritative regional energy statistics.

Significant differences exist in carbon emissions among the three disposal scenarios. The traditional landfilling scenario generates the highest total carbon emissions of 89.36 $kgCO_2e$, mainly stemming from long-distance transportation, landfill operation and waste degradation, with zero emission reduction gains. Benefiting from short-distance transportation and simplified processing procedures, the on-site recovery scenario drastically cuts carbon emissions from transportation and disposal, with total carbon emissions of merely32.15 $kgCO_2e$. The industrial recycled aggregate utilization scenario produces certain carbon emissions from energy consumption in crushing and screening processes, yet the emission reduction gains from replacing natural building materials with recycled aggregates offset part of processing emissions, resulting in comprehensive carbon emissions between the other two scenarios.

4.2. Analysis of Carbon Emission Reduction Benefits

Taking the traditional landfilling scenario as the benchmark, Table 2 quantifies the carbon emission reduction volume and reduction rate of the two resource utilization modes.

Resource utilization modes deliver remarkable low-carbon emission reduction advantages compared with traditional landfilling. The on-site resource recovery mode achieves optimal emission reduction effects, with a single-ton emission reduction volume of 57.21 $kgCO_2e$ and a reduction rate exceeding 64%, highly suitable for scattered construction project disposal in counties and suburban areas of Anhui Province. The industrial recycled aggregate utilization mode maintains a stable reduction rate close to 49%. Despite carbon emissions generated by energy consumption in production and processing, its circular resource substitution benefits are prominent, fitting large-scale and industrial solid waste disposal scenarios in core cities within the province. Overall, the resource utilization of construction waste in Anhui Province boasts huge low-carbon potential, serving as an effective pathway for carbon reduction in the regional construction industry.

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Table 2. Comparison of Carbon Emission Reduction Benefits of Resource Utilization Modes

Mode Comparison	Emission Reduction Volume per Ton ($kgCO_2e$)	Carbon Emission Reduction Rate (%)	Emission Reduction Characteristics
On-Site Recovery vs. Traditional Landfilling	57.21	64.02	Short-distance transportation delivers prominent advantages, substantially cutting carbon emissions from transportation and landfill degradation
Industrial Recycled Aggregate Utilization vs. Traditional Landfilling	43.64	48.84	High energy consumption in production and processing, yet outstanding emission reduction gains from natural building material substitution

Note: Emission reduction volume is calculated based on the traditional landfilling benchmark scenario; the reduction rate represents the carbon emission reduction proportion of resource utilization modes relative to landfilling.

4.3. Sensitivity Analysis

To identify key factors affecting regional carbon emission reduction benefits, three core parameters including transportation distance, power grid carbon emission factor and recycled product substitution rate are selected for single-factor sensitivity analysis with fluctuation ranges of ±10% and ±20%.

Table 3. Summary of Parameter Sensitivity Analysis Results

Influencing Parameter	Fluctuation Range	Relative Change Rate of Total Carbon Emissions (%)	Sensitivity Coefficient	Sensitivity Level
Transportation Distance	-20%	-18.76	0.94	High Sensitivity
	-10%	-9.32	0.93	
	+10%	9.28	0.93	
	+20%	18.64	0.93	
Recycled Product Substitution Rate	-20%	-7.82	0.39	Medium Sensitivity
	-10%	-3.91	0.39	
	+10%	3.89	0.39	
	+20%	7.78	0.39	
Power Grid Carbon Emission Factor	-20%	-4.24	0.21	Low Sensitivity
	-10%	-2.11	0.21	
	+10%	2.09	0.21	
	+20%	4.18	0.21	

Note: Sensitivity coefficient = Relative Change Rate of Carbon Emissions / Parameter Fluctuation Rate; the larger the absolute value of the coefficient, the greater the parameter's influence on carbon emissions.

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Analysis of Table 3 reveals obvious hierarchical differences in the influence degree of the three parameters on carbon emissions of construction waste in Anhui Province. Transportation distance features the highest sensitivity coefficient (approximately 0.93) and is classified as a highly sensitive factor. Increases or decreases in transportation distance cause drastic fluctuations in full-chain carbon emissions, making it the core factor governing regional emission reduction benefits. The recycled product substitution rate has a sensitivity coefficient of roughly 0.39, representing a medium-sensitive factor; raising the substitution rate can effectively improve emission reduction levels of industrial resource utilization modes. The power grid carbon emission factor only has a sensitivity coefficient of 0.21, a low-sensitive factor exerting relatively mild impacts on overall carbon emissions. In conclusion, low-carbon solid waste governance in Anhui Province should prioritize transportation link management, continuously increase the proportion of recycled product substitution, and supplement with optimization of regional energy structures to efficiently boost carbon emission reduction benefits.

5. Conclusion and Countermeasures

5.1. Research Conclusion

Based on the LCA method, this paper constructs a carbon accounting system for construction waste resource utilization in Anhui Province. Through multi-scenario calculation and sensitivity analysis, it systematically quantifies regional carbon emission reduction benefits of solid waste recycling, drawing the following main conclusions:

(1)Resource utilization delivers prominent low-carbon advantages over traditional landfilling, with emission reduction rates of 64.02% and 48.84% for on-site recovery and industrial recycled aggregate utilization respectively, forming an effective pathway for carbon reduction in Anhui's construction industry.

(2)Significant differentiation exists in emission reduction efficiency among different resource utilization modes: on-site recovery adapts to short-distance disposal scenarios in counties, while industrial recycled aggregate utilization fits large-scale and industrial circular resource recovery scenarios.

(3)Transportation distance, recycled product substitution rate and regional energy structure are core sensitive factors affecting carbon emission reduction benefits of construction waste in Anhui Province, with transportation link management ranking the highest in priority.

5.2. Countermeasures and Suggestions

(1)Optimize transportation layout to cut carbon emissions from transfer. Coordinate the layout of regional construction waste disposal stations based on municipal construction distribution in Anhui Province to shorten transportation distances between construction sites and disposal plants. Promote new energy transport vehicles, standardize transfer routes and reduce energy consumption from empty loads and detours to cut carbon emissions of transportation links from the source.

(2)Promote classified resource utilization modes. Popularize on-site crushing and recovery modes for scattered projects in suburban and county areas to lower disposal costs and carbon emissions. For core cities such as Hefei and Wuhu, build large-scale recycled building material industrial parks to raise centralized resource utilization rates of waste and recycled product substitution rates, amplifying circular carbon reduction benefits.

(3)Drive low-carbon upgrading of resource recycling industry. Guide domestic recycled building material enterprises to optimize production processes and introduce energy-saving processing equipment to reduce energy consumption in industrial processing. Leverage Anhui's new energy development advantages to equip disposal plants with photovoltaic power generation and replace fossil power with green electricity, optimizing energy structures and cutting carbon emissions from industrial processing links.

(4)Improve regional low-carbon policy regulation systems. Establish localized low-carbon accounting standards for construction waste resource utilization in Anhui Province, and incorporate carbon emission reduction benefits into industrial assessment systems. Introduce supporting policies for recycled product promotion, encouraging municipal and housing construction projects to prioritize recycled aggregates and recycled building materials, and continuously lift resource substitution levels.

6. Research Limitations and Prospects

This paper only focuses on the single carbon environmental benefit of construction waste, without collaborative analysis of economic and social benefits. Minor parameter differences such as seasonal working conditions and construction types are not incorporated into the calculation of results. Future research can construct a multi-dimensional benefit evaluation model covering economy, environment and resources, combined with multi-objective optimization algorithms to explore the optimal low-carbon regulation path for construction waste resource utilization in Anhui Province, providing more comprehensive theoretical support for regional circular and low-carbon development of solid waste.

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