Research on the establishment and practical path of the green factory evaluation system in the plastics machinery industry

—In-depth analysis based on the T/CPCIF 0309-2023 group standard

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Abstract: This paper focuses on the group standard T/CPCIF 0309—2023, "Evaluation Requirements for Green Factories in the Plastics Machinery Industry," as the core research object. It analyzes the six primary indicators, including infrastructure and performance, outlined in the standard, and provides a detailed examination of the three-tiered target system consisting of baseline, advanced, and leading values for performance indicators. The paper proposes a four–stage implementation path, namely "diagnostic planning –system construction–key breakthroughs–continuous optimization," along with differentiated strategic recommendations tailored for enterprises at different stages of development. The aim of this study is to offer systematic theoretical support and practical guidance for the construction of green factories in the plastics machinery industry, while also providing a methodological framework that can be referenced for the development of green standards in other manufacturing subsectors.

Key words: green factory; plastic machinery; evaluation system; life cycle assessment; clean production; sustainable development

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0 Introduction

Driven by China's "dual carbon" strategy, the construction of green factories has become pivotal for the transformation of the manufacturing industry. The "14th Five-Year Plan for Green Industrial Development" issued by the Ministry of Industry and Information Technology explicitly outlines the "five modernizations" goals. As an important equipment manufacturing sector, the plastic machinery industry faces challenges such as high energy consumption and high emissions in its production process. To address these issues, the China Petroleum and Chemical Industry Federation released the "Evaluation Requirements for Green Factories in the Plastic Machinery Industry" (T/CPCIF 0309-2023) in December 2023. This study aims to interpret and analyze the T/CPCIF 0309-2023 standard. The specific research includes: first, an in-depth analysis of the background, compilation principles, and technical basis of the standard; second, a systematic deconstruction of the evaluation index system established by the standard; third, a focused interpretation of the performance evaluation section to verify the scientificity and guidance of the three-level target value setting; fourth, combining the actual operation of plastic machinery enterprises to construct an implementation path and action plan for green factory construction; fifth, proactively exploring potential challenges that may be encountered during the implementation of the standard and proposing corresponding policy recommendations and safeguard mechanisms to promote the

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effective implementation and continuous improvement of the standard. Through the above research, it is expected to provide a solid theoretical reference and practical guidance for plastic machinery enterprises to practice green manufacturing, relevant institutions to conduct evaluation and certification, and government departments to formulate industrial policies.

1 Analysis of the background, principles, and process of standard development

1.1 Policy-driven and inherent industry demand

The formulation of this standard directly responds to the policy requirements outlined in the national "14th Five-Year Plan" for industrial green development, which aims to establish and improve a green standard system. It is designed to concretize the national green manufacturing strategy in the plastic machinery industry. Although China's plastic machinery industry is large in scale, the level of greenization varies greatly, which restricts industrial upgrading. The lack of unified green evaluation standards within the industry leads to unclear directions for corporate transformation. At the same time, green barriers in the international market are becoming stricter, posing challenges to product exports. Therefore, formulating industry standards that are both in line with national conditions and internationally compatible is crucial for regulating the industry, leading technology, and enhancing competitiveness.

1.2 Rigorous, transparent, consensus-driven development process

The formulation of this standard took more than two years. The project was officially initiated in November 2022 and organized by the National Technical Committee for Rubber and Plastics Machinery Standardization. A drafting working group consisting of 20 units was established, including leading enterprises, scientific research institutions, and testing organizations. A working mode combining "industry, academia, research, and testing" was formed to ensure the progressiveness and operability of the standard. The drafting process went through multiple rounds of discussion and revision, and public opinions were solicited from April to May 2023. A total of 41 opinions were received, which were handled and fed back by the working group one by one, ultimately forming a draft for review. This open process significantly improved the industry acceptance and authority of the standard.

1.3 Core compilation principles: Unification of scientificity, progressiveness, and operability

This standard strictly follows the rules for writing standardized documents, adhering to the unity of scientificity, progressiveness, and operability. Scientificity is reflected in the framework of the national standard GB/T 36132—2018 "General Principles for Evaluation of Green Factories", and more than 30 relevant national standards are referenced to ensure technical consistency. Progressiveness is manifested not only in setting basic "mandatory requirements", but also in guiding enterprises to pursue excellence through "optional requirements" and "leading values". Its prominent feature is operability: the three-level target values (baseline value, advanced value, and leading value) of key performance indicators are determined based on repeated calculations and verifications using real production data from the drafting unit, ensuring that the standard is "down-to-earth" and can effectively guide enterprise positioning and improvement.

2 Systematic Deconstruction and Core Features of the Standard Evaluation System

This standard establishes a comprehensive evaluation system for green factories that is logically rigorous, hierarchically distinct, and comprehensively covered. This system can be summarized as a three-tier framework, with "basic requirements" as the entry ticket, "six major evaluation indicators" as the core of process assessment, and "performance indicators" as the benchmark for result quantification. It employs a weighted scoring method for quantitative evaluation, with a total score of 100 points.

2.1 Basic requirements of the "one-vote veto system": the bottom line and premise of green development

The basic requirements section sets rigid thresholds for enterprises participating in the evaluation of green factories, adopting a "one-vote veto system", where any non-compliance will result in disqualification from the evaluation. This reflects the bottom-line thinking of green development, that is, green factories must first be lawful, compliant, orderly managed,

safe, and reliable. The specific requirements are divided into two aspects:

(1) In terms of basic compliance and stakeholder requirements, enterprises must demonstrate strict adherence to national and local laws and regulations throughout the entire construction and production process; they must not have experienced major or above safety, quality, or environmental accidents in the past three years, nor have any relevant administrative penalties recorded; they must have fulfilled their environmental commitments made to stakeholders; and they must not be listed on the list of severely illegal and dishonest enterprises. These clauses directly link the enterprise's record of law-abiding integrity with green evaluation.

(2) In terms of basic management responsibilities, the standard sets clear requirements for the top management of enterprises: they must play a substantial leadership role in the construction of green factories and make public commitments; and ensure clear allocation, communication, and responsibility and authority related to green factories within the organization. In addition, the overall management mechanism of the factory must meet the general requirements for green factory management as outlined in GB/T 36132. These requirements aim to drive green transformation from the management level, ensuring that green work has clear responsibilities and accountability.

2.2 Six core evaluation indicator systems: whole-process and multi-dimensional green management

The six indicators provide a process-based evaluation of the greening level of factories from different dimensions, with their weight distribution reflecting their respective importance.

2.2.1 Infrastructure (weight: 20%) - the highest weight, emphasizing hardware foundation

Infrastructure serves as the physical foundation for green factories, and its level of greenification is fundamental, pioneering, and long-term. This aspect demands meticulous and comprehensive attention:

(1) Buildings: It is not only required to comply with regulations, but also encouraged to integrate green concepts from the design stage, adopt energy-saving materials and structures, fully utilize natural lighting and renewable energy, and mandatorily require independent setups for operating rooms that generate pollutants (such as paint spray booths and welding rooms) to prevent cross-contamination.

(2) Lighting: Specific quantitative indicators have been proposed, such as "the proportion of energy-saving lighting equipment used should not be less than 50%", and the adoption of control strategies such as intelligent zoning and timed dimming is encouraged. Precise energy conservation is achieved while ensuring safety (e.g., using explosion-proof lights in explosive environments).

(3) General and Special Equipment: It is required to adopt advanced equipment that is efficient and low-energy consumption, and to phase out outdated equipment explicitly prohibited by the state within a specified timeframe. Specific compliance requirements for energy consumption and emissions have been proposed for 24 types of equipment unique to the plastics machinery industry, such as automatic spraying lines, mold temperature machines, and ultrasonic cleaning machines.

(4) Metering equipment: It is required to equip with metering instruments for energy, water, and other resources in accordance with national standards, and establish a comprehensive ledger and management system. This serves as the data foundation for achieving refined energy and resource management.

(5) Pollutant treatment processes and equipment: It is mandatory to equip with VOCs collection and treatment facilities and establish operation logs; actively promote source cleaning processes such as replacing oil-based paints with water-based paints and replacing traditional phosphating with silane treatment. These requirements directly address the pain points of environmental protection in the industry.

2.2.2 Management system and social responsibility (weight: 15%) - emphasizing soft power and external communication

Green manufacturing cannot be achieved without a systematic management system and proactive social responsibility.

(1) Five management systems: The standards require enterprises to establish, implement, and maintain a quality management system (ISO 9001), an environmental management system (ISO 14001), and an occupational health

and safety management system (ISO 45001), and they must be certified by a third party. At the same time, enterprises are encouraged to establish and certify an energy management system (ISO 50001) and a measurement management system.

(2) Social responsibility: This is a prominent innovation. The standard lists "publicly releasing social responsibility reports annually" as a mandatory requirement, compelling enterprises to transparently disclose their performance in environmental protection, safe production, and other aspects to the society.

2.2.3 Energy and resource input (weight: 15%) - focusing on green and efficient inputs.

This indicator aims to promote enterprises to achieve reduction, harmlessness, and recycling at the source of production inputs.

(1) Energy input: It is required to optimize the energy structure, reduce dependence on fossil fuels, encourage the use of renewable energy such as photovoltaic power generation, and fully utilize waste heat from production.

(2) Resource input: It is required to reduce the use of harmful chemicals and assess the feasibility of substitution; encourage the use of recycled and recyclable materials; and require a full-process consumption analysis of key materials to improve material utilization.

(3) Procurement and Green Supply Chain: It is required to incorporate environmental protection requirements into supplier selection and evaluation criteria, ensuring the green attributes of purchased products. Enterprises are encouraged to establish green supply chains and prioritize purchasing products from green factories.

2.2.4 Products (weight: 10%)——Promoting the downstream transmission of green value.

Green factories should not only ensure green production processes, but also ensure that their products possess green attributes.

(1) Eco-design: It requires the systematic introduction of eco-design concepts into product design, and encourages the conduct of Life Cycle Assessment (LCA) to consider the resource and environmental impacts throughout the entire product lifecycle from its inception.

(2) Hazardous substance restrictions: Promote the substitution of water-based paints for oil-based paints, environmentally friendly cleaning agents for solvent-based cleaning agents, and other material substitutions to reduce the content of hazardous substances in products.

(3) Energy conservation and carbon reduction: Require products to meet national energy efficiency standards, encourage enterprises to calculate and disclose the carbon footprint of their products, and guide the development of low-carbon products.

(4) Recyclability: Encourage the calculation and improvement of product recyclability, require the use of environmentally friendly packaging materials, and strengthen the recycling of waste steel materials during the production process.

2.2.5 Environmental emissions (weight: 10%) - Strengthen end-of-pipe control and compliance management

This section sets strict closed-loop management requirements for various types of environmental emissions generated during factory operations.

(1) Air pollutants: Focus on particulate matter, SO_2, NOx, VOCs, etc., requiring emissions to meet standards, and mandating the installation of collection and purification devices for VOCs-generating processes (paint mixing, spraying, etc.).

(2) Water pollutants: It is required that wastewater be discharged in compliance with standards. An automatic monitoring device should be installed at the main discharge outlet of the plant, and an emission logbook should be established.

(3) Solid waste: Strict implementation of classified management is required. Hazardous waste must be disposed of by qualified units and subject to the transfer joint sheet system.

(4) Greenhouse gases: Enterprises are required to account for and report greenhouse gas emissions within their factory boundaries, and are encouraged to publish the results and utilize them for emission improvement.

2.2.6 Performance (weight: 30%) - Quantitative core oriented towards results

Performance indicators serve as the "touchstone" of the evaluation system, carrying the highest weight and fully embodying the principle of result orientation. They quantitatively assess the green operational achievements of

factories and innovatively set three levels of targets for each indicator: benchmark value, advanced value, and leading value (as shown in Table 1). The benchmark value represents the basic requirements for industry entry, the advanced value signifies a better level in the industry, and the leading value symbolizes an industry benchmark.

Table 1 Three-level target value system for performance indicators of green factories in the plastic machinery industry

First-Level Indicator	Secondary Indicator	Specific Indicators	Unit	Reference Value	Advanced Value	Leading Value
Performance	Land use intensification	floor area ratio	-	1.0	1.3	1.6
		building density	%	45	60	75
		Output value per unit of land area	¥$10^4/m^2$	0.4	0.7	1.0
	Harmless treatment of raw materials	Utilization rate of green materials	%	60	70	80
	Clean Production	Emission of major pollutants per unit of product	kg/t	6	4	2
		Waste gas emission per unit product	m^3/t	20,000	10,000	5,000
		Wastewater discharge per unit of product	m^3/t	0.20	0.15	0.10
	Waste recycling	Consumption of main raw materials per unit of product	kg/t	800	700	600
		Comprehensive utilization rate of industrial solid waste	%	80	85	90
	Low-carbon energy transition	Comprehensive energy consumption per unit of product	kgce/t	60	40	20

2.3 Prominent features and innovative value of the evaluation system

2.3.1 In-depth industry customization

The standard is by no means a mere copy of the national standard. Its provisions closely align with the process chain, material flow, and pollution characteristics of the plastics machinery industry, exhibiting strong pertinence.

2.3.2 Empirical data-driven

The performance target values are calculated based on real enterprise data, avoiding the problem of "castle in the air" where standards are divorced from reality, and are scientific and credible.

2.3.3 Hierarchical guidance mechanism

The three-tiered target values establish a clear hierarchy of "catching up (baseline) - surpassing (advanced) - leading (pioneering)", effectively motivating enterprises with varying starting points to continuously improve.

2.3.4 Integration of management and social responsibility

The equal emphasis on soft requirements such as system certification and social responsibility reports, alongside hardware transformation, reflects a comprehensive understanding of the essence of green manufacturing.

2.3.5 Perspective of supply chain extension

By implementing green procurement requirements, we can transmit green pressures and motivations to the supply chain, thereby amplifying the industrial value of individual factories' green transformation.

3 In-depth analysis, empirical verification, and improvement directions of key performance indicators

Performance indicators are crucial for the implementation of standards, and the scientific nature of their calculation methods and the reasonableness of their target values directly impact the fairness and directionality of evaluations.

3.1 Scientificity of calculation method and data basis

Appendix A provides clear calculation formulas for 10 performance indicators, defining the calculation boundaries, data sources, and units. For example, the calculation of plot ratio clarifies the rule of doubling the area when the building height exceeds 8 meters; all unit product indicators are standardized with "product weight" as the denominator, enhancing the comparability between different types and specifications of products. The standard emphasizes that data should come from standardized statistical ledgers and monitoring records, ensuring the traceability and authenticity of the calculation results. This design provides a clear and verifiable basis for performance evaluation.

3.2 Empirical basis and verification of the setting of tertiary target values

Using the actual operational data from a factory of a large plastic machinery enterprise in 2022 as a sample, detailed

calculations were conducted on various performance indicators, providing a valuable perspective for understanding target value setting.

(1) Intensive land use: The measured plot ratio of the factory is 1.61, and the building density is 49.79%. The plot ratio of 1.61 exceeds the leading value (1.6) set by the standard, indicating that the setting of the leading value is not unattainable; the building density of 49.79% falls between the benchmark value (45%) and the advanced value (60%), indicating that there is still room for improvement in this indicator. This verifies the differentiation and reality of the target value system.

(2) Harmless raw materials: Taking the bill of materials (BOM) of an injection molding machine (UN260) as an example for calculation, if we broadly define green materials (excluding only explicitly harmful items such as chrome-plated parts and oil paint), the utilization rate of green materials can reach as high as 98.4%; if we define it strictly (also considering the environmental compliance of processes such as galvanizing and printing), the utilization rate drops to 74.9%. This calculation process reveals the importance of defining "green materials", and also illustrates that setting the advanced value at 70% and the leading value at 80% for the standard is challenging, which can promote enterprises to deepen green management in their supply chains.

(3) Production cleanliness and energy decarbonization: Specific values such as the amount of waste packaging barrels generated per unit product (1.27 kg/unit) and the comprehensive energy consumption (0.08 tons of standard coal/unit) were calculated. These actual data provide a benchmark reference for the industry to understand its own emission and energy consumption levels.

Empirical verification indicates that this set of performance indicator system and its target values originate from practice, guide practice, and possess good operability and clear guiding roles.

3.3 Potential improvement directions for the performance indicator system

Although the current indicator system is relatively well-established, there is still room for optimization from a development perspective:

(1) Indicator expansion: Consider adding indicators such as "water resource reuse rate" and "renewable energy use ratio" to more comprehensively reflect the level of resource recycling and energy structure optimization.

(2) Refinement of calculation methods: For the carbon footprint accounting of products, it is advisable to clarify the accounting boundaries (such as whether to include the upstream supply chain) and suggestions for the emission factor database in the future.

(3) Dynamic management of target values: It is recommended to establish a regular mechanism for collecting and analyzing industry data. Based on the overall technological progress of the industry, performance target values (especially advanced and leading values) should be reviewed and adjusted every 3-5 years to ensure that the standards continue to lead the industry development.

(4) Integration with digital technology: Encourage enterprises to utilize the Internet of Things and big data technology to achieve real-time collection and automatic calculation of energy consumption and emission data, thereby enhancing the intelligence level and data accuracy of performance management.

4 Systematic implementation path for green factory construction in plastic machinery enterprises

Based on the requirements of the T/CPCIF 0309—2023 standard, the construction of green factories by plastic machinery enterprises is not a quick accomplishment, but rather a strategic project that requires systematic planning and step-by-step implementation. This article constructs a closed-loop implementation path model consisting of four core stages and eight key steps to guide enterprises in advancing in an orderly manner. The implementation path model is shown in Figure 1.

4.1 Phase 1: preparation and diagnosis - unify thinking and get a clear understanding of the situation

Step 1: Organizational construction and full-staff implementation: Establish a "Green Factory Construction Leadership Group" led by the top management of the enterprise, responsible for strategic decision-making and resource coordination; set up a "Working Group" composed

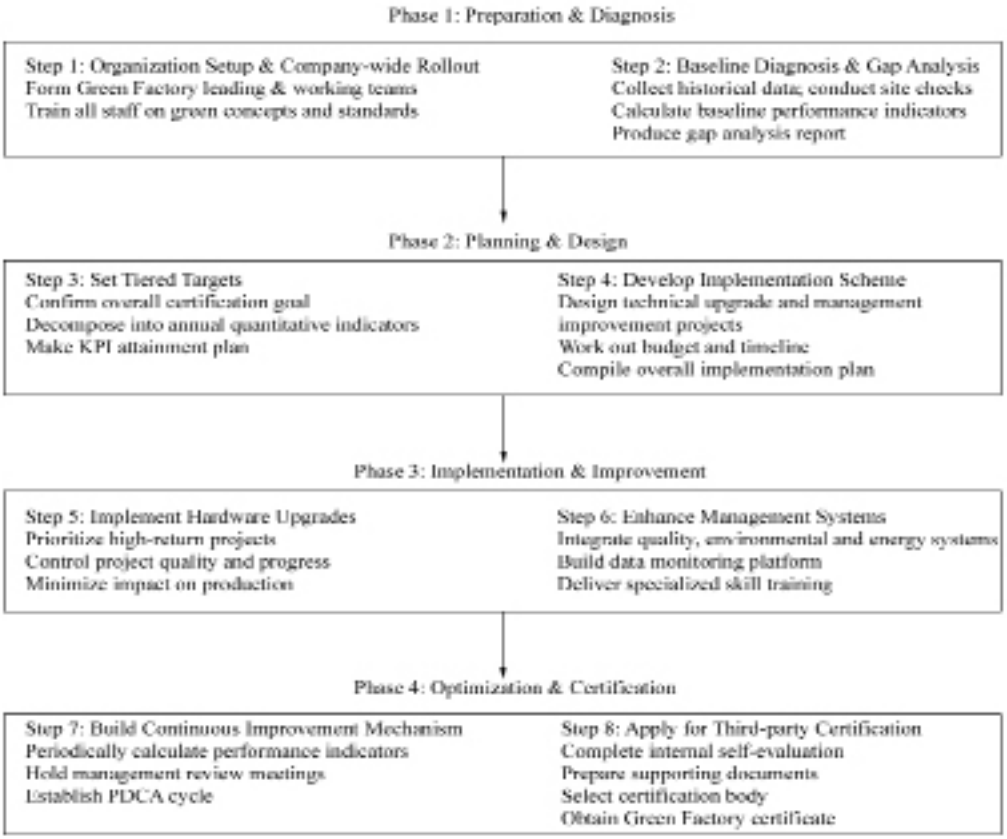


Figure 1 Implementation path model diagram

of key personnel from production, technology, safety and environmental protection, energy, procurement, and other departments, responsible for specific implementation. Carry out implementation training covering all staff, focusing on interpreting national policies, industry trends, and the specific requirements of the T/CPCIF 0309—2023 standard.

Step 2: Comprehensive current status diagnosis and gap analysis: Enterprises need to systematically collect historical data from the past 1-3 years, including energy purchase and consumption bills, water resource consumption records, major raw material procurement and consumption ledgers, monitoring reports and transfer forms for various pollutants (waste gas, waste water, solid waste), product output and output value data, and existing management system certificates. At the same time, organize a cross-departmental team to conduct on-site inspections to verify equipment energy efficiency, pollution control facility operating status, material storage and management conditions, etc. Calculate the current values of various performance indicators and form a detailed "Green Factory Construction Gap Analysis Report".

4.2 Phase 2: Planning and design - setting goals and developing a blueprint

Step 3: Scientifically set graded objectives: Combine corporate strategy, resource status, and gap analysis report to scientifically set the overall goal for the construction of a green factory (for example: to pass provincial-level green factory certification within two years and reach the national-level green factory standard within five years). And break down the overall goal into quantifiable and assessable annual or phased objectives.

Step 4: System design implementation plan: Design improvement plans, including technical transformation projects requiring capital investment (such as water-based transformation of spraying lines, upgrading of VOCs treatment facilities, etc.) and management improvement projects (such as integrating and improving integrated management system documents, optimizing green procurement processes, etc.). Finally, prepare a detailed Overall Implementation Plan for

Green Factory Construction.

4.3 Phase III: Implementation and improvement - focusing on implementation and systematic improvement

Step 5: Promote hardware technology transformation in an orderly manner: According to the implementation plan, prioritize projects with high return on investment, significant environmental benefits, and mature technology. During implementation, focus on project management to ensure project quality and progress.

Step 6: Comprehensively deepen the construction of management system: Simultaneously promote the enhancement of management soft power. Promote the deep integration of quality, environmental, energy, and occupational health and safety systems to avoid operating with "multiple skins". Establish and improve a digital monitoring platform covering energy, resources, environment, and carbon data, enabling automatic collection, statistics, and analysis of key data, providing real-time support for management decision-making and performance calculation.

4.4 Phase 4: Optimization and certification - consolidating achievements, pursuing excellence

Step 7: Establish a performance monitoring and continuous optimization mechanism: Enterprises should establish a regularized mechanism for performance monitoring, review, and improvement. Calculate performance indicators on a regular basis (such as quarterly or semi-annually), hold management review meetings, analyze trends, identify new opportunities for improvement, and incorporate them into the next round of action plans, forming a virtuous cycle of "Plan - Do - Check - Act" (PDCA).

Step 8: Apply for third-party evaluation and certification: When the enterprise is confident that it has fully met the standard requirements, it can initiate the certification process. Firstly, conduct a rigorous internal self-evaluation based on the scoring table in Appendix B and prepare complete evidence documents. Then, select a third-party certification body approved by the Certification and Accreditation Administration of the People's Republic of China and qualified for green factory evaluation to submit an application. Actively cooperate with the certification body's document review and on-site audit, and promptly rectify any non-conformities found during the audit. Finally, obtain the green factory certificate upon passing the certification, use the logo as required, accept supervision, and maintain the validity of the certification.

4.5 Differentiated implementation strategies for enterprises of different sizes

4.5.1 Leading enterprises in the industry

We should aim high and set "industry benchmark" and "international advanced level" as our goals. In terms of implementation path, we emphasize systematicness and leadership: carrying out comprehensive green strategic planning; increasing R&D investment to achieve breakthroughs in low-carbon processes and intelligent environmental protection equipment; leading the construction of a green supply chain to drive collaborative transformation of upstream and downstream industries.

4.5.2 Medium-sized growth enterprises

We should focus on effectiveness and differentiated development. We can adopt the strategy of "making breakthroughs in key areas and leveraging them to expand to other areas", concentrating resources to prioritize addressing the most prominent issues related to energy consumption or emissions, and creating several iconic green demonstration projects or workshops. By combining green improvements with product characteristics and market positioning, we can form a unique green competitiveness.

4.5.3 Small and start-up enterprises

We should be grounded in reality, with compliance and standard-reaching as well as basic improvement as our primary tasks. Firstly, we must ensure that all production and operation activities comply with basic national regulations on environmental protection and safety. We should start with low-cost or no-cost measures such as improving on-site 5S management, sharing environmental protection facilities, enhancing employees' awareness of energy conservation, and optimizing simple process flows. Actively understand and strive for support policies from local governments, such as special funds and tax incentives, in the areas of green transformation, energy conservation, and emission reduction. Low-cost cases that small enterprises can implement are as follows:

4.5.3.1 Shared environmental protection facilities model:

Within industrial parks or industrial clusters, multiple small enterprises can jointly invest in the construction of shared:

(1) Centralized VOCs treatment center: Enterprises collect the exhaust gas generated during the spraying process through pipelines and send it to the center for unified treatment, sharing the construction and operation costs.

(2) Centralized temporary storage and transfer points for hazardous waste: A shared hazardous waste warehouse constructed in accordance with regulations, which is managed and transferred by a professional company in a unified manner, reducing the compliance costs for individual enterprises.

(3) Wastewater pretreatment facilities: Centralized pretreatment of similar production wastewater is conducted before it is discharged into the municipal sewer network, ensuring that it meets emission standards.

4.5.3.2 Measures to enhance low-cost management

(1) On-site 5S + green improvement: Integrate green requirements into 5S management, such as setting up classified trash bins and indicating the on/off status of energy-consuming equipment.

(2) Simple data collection: Establish a manual ledger using Excel tables, and systematically record key energy and material consumption data to provide a basis for improvement.

(3) Utilization of policy dividends: Actively apply for energy-saving subsidies and tax incentives for purchasing environmental protection equipment from local governments for small and medium-sized enterprises.

5 Challenges, safeguard mechanisms, and policy recommendations for standard implementation

5.1 Main challenges faced in current implementation

The comprehensive and effective implementation of the T/CPCIF 0309-2023 standard is expected to face the following challenges:

(1) Insufficient corporate awareness and capability: Some enterprises, especially small and medium-sized enterprises (SMEs), have a limited understanding of the rich connotation of green factories, still remaining at the level of "end-of-pipe treatment," and exhibit a reluctance towards the systematic and progressiveness requirements of standards. At the same time, there is a lack of composite green talents within the enterprise who possess both technical and management expertise.

(2) Initial transformation cost pressure: Especially for the green transformation of hardware facilities (such as VOCs high-efficiency treatment equipment, energy management systems), a large one-time investment is required, which may put pressure on the short-term cash flow of enterprises and affect their investment enthusiasm.

(3) Data foundation and management shortcomings: Many enterprises, especially those with extensive management practices, lack complete equipment for energy measurement instruments and non-standardized environmental monitoring data recording. This results in a lack of accurate and complete data support for performance indicator calculations, making self-evaluation difficult to conduct.

(4) Complexity of the evaluation system and maturity of the third-party market: The standard system is relatively complex, making it difficult for enterprises to accurately understand and apply it on their own. At the same time, there are currently only a limited number of third-party certification bodies with experience in green factory evaluation and a deep understanding of the plastics machinery industry, and the quality and consistency of evaluation services need to be improved.

5.2 Establish a multi-party collaborative safeguard mechanism

To address the aforementioned challenges, it is necessary to establish a multi-party collaborative safeguard mechanism that combines government guidance, industry services, enterprise entities, and market drive.

(1) Organizational guarantee: Industry and information technology departments at all levels should take the lead and collaborate with departments such as ecology and environment, market supervision, etc., to form a policy synergy and incorporate the construction of green factories into local industrial green development assessments.

(2) Technical support: Support research institutes and leading enterprises in jointly establishing a "Plastic Machinery Green Manufacturing Innovation Center" or a public service

platform. Conduct research and development to tackle common key technologies in the industry, and provide services such as technical diagnosis and scheme design for small and medium-sized enterprises.

(3) Financial support: Innovative financing support methods. In addition to the existing special funds for energy-saving technological transformation, we should vigorously develop green finance, encourage financial institutions to develop exclusive credit products such as "green factory upgrade loans", and offer preferential interest rates.

(4) Capability assurance: Incorporate green manufacturing courses into the engineering education system. Industry associations and standardization committees regularly organize standard promotion, case sharing, and capability building training sessions to cultivate urgently needed professionals in green management, energy management, and other related fields for enterprises.

5.3 Policy suggestions for promoting the in-depth development of standards

To ensure that standards continue to play a leading role, the following policy suggestions are proposed:

(1) Strengthen incentive and credit policies: It is recommended that governments at all levels consider the evaluation results of green factories as an important corporate credit qualification, and provide substantial preferential treatment and convenience in project approval, government procurement, brand selection, environmental protection supervision, and other aspects, significantly enhancing enterprises' "sense of green gains".

(2) Improve supporting facilities and implementation tools: Encourage industry associations to take the lead in compiling supporting documents such as the "Recommended Catalogue of Green Technologies/Equipment for the Plastics Machinery Industry", and develop online self-evaluation simulation tools or calculation software to reduce the application threshold for enterprises.

(3) Cultivate a professional and standardized third-party market: Strengthen the training and supervision of certification bodies, establish an evaluation expert database and an institutional capacity assessment mechanism, to ensure the professionalism, fairness, and consistency of the evaluation process.

(4) Establish a mechanism for standard dynamic revision and data sharing: It is recommended that standard-setting units establish a regular industry data research mechanism, and conduct reviews and necessary revisions of standards every 3-5 years based on technological development, policy changes, and industry level improvements. Explore the establishment of an industry green performance data sharing platform to provide big data support for scientific revision of standards and industry benchmarking.

(5) Promoting international exchanges and standard alignment: Encourage domestic experts and institutions to actively participate in activities organized by international standardization organizations such as ISO in the fields of green manufacturing and product environmental footprint. Promote the translation of green practices in China's plastic machinery industry into international standard proposals. Facilitate the alignment and mutual recognition between the T/CPCIF 0309—2023 standard and relevant international standards and regulations, thereby aiding Chinese plastic machinery products in penetrating the global green market.

6 Conclusion and outlook

The release and implementation of T/CPCIF 0309—2023 "Evaluation Requirements for Green Factories in the Plastics Machinery Industry" marks an important milestone in the journey towards high-quality development of China's plastics machinery industry. This study, through an in-depth analysis of this standard, demonstrates that it is a specialized evaluation system for the industry that is scientific, systematic, distinctive, and highly operable. It provides a clear "roadmap" and "health checklist" for green transformation for plastics machinery enterprises through a three-tier structure of "basic requirements - process indicators - performance results" and a three-level objective system of "baseline - advanced - leading". The standard extends the green concept from single environmental protection to a comprehensive enhancement of infrastructure, management systems, product ecology, supply chain responsibility, and even corporate social image, profoundly interpreting the rich connotation of modern green manufacturing.

Looking ahead, the journey towards green manufacturing is long and arduous. As an outstanding achievement in the

current stage, the T/CPCIF 0309—2023 standard itself should also continue to evolve in practice. We anticipate that with the deep integration of new technologies such as smart manufacturing and industrial internet, future evaluations of green factories will become more intelligent and dynamic; as the "dual carbon" goals are further advanced, the calculation and control of carbon footprint across the entire product lifecycle will become more precise and stringent; and as a global green governance system takes shape, the green standards and practices of China's plastics machinery industry will exert greater influence on the international stage. We firmly believe that, guided by this standard and through the joint efforts of the government, industry, enterprises, and society, China's plastics machinery industry will surely build strong green competitiveness, not only in terms of scale but also in quality and sustainability, truly leading the green revolution in the global plastics machinery manufacturing industry and contributing Chinese wisdom and solutions to the construction of a global ecological civilization.

