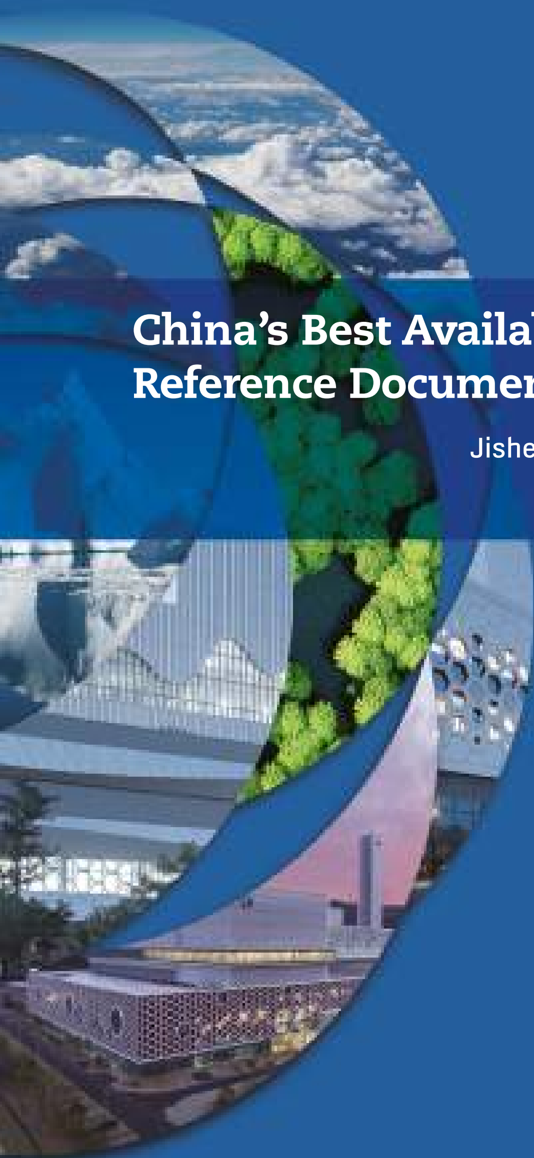
ENERGY & WASTE MANAGEMENT



China's Best Available Techniques (CBAT) – Reference Document for Waste Incineration

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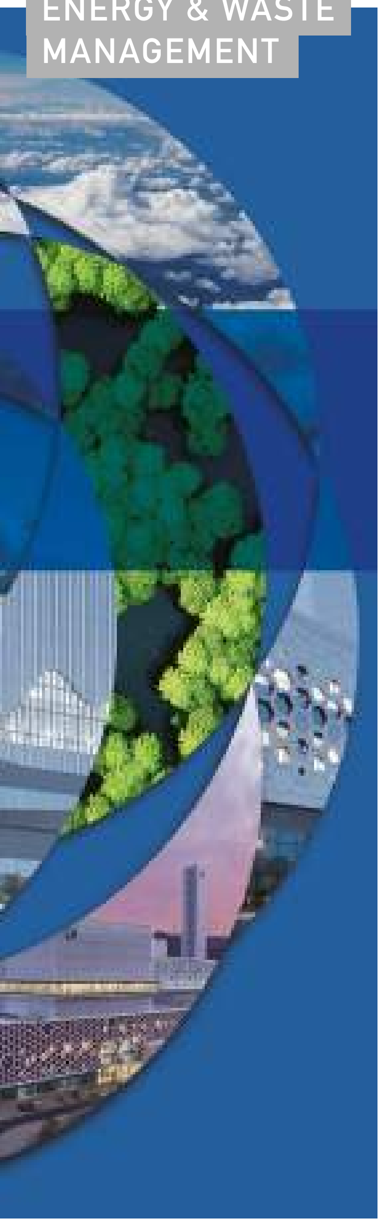

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As China's urbanization rate surpasses 65%, municipal solid waste in Chinese cities exceeds 250 million tons annually. Safe and sustainable waste management has become an unavoidable challenge. Municipal solid waste incineration for power generation, offering reduction, resource recovery, and harmless treatment, has evolved from early exploratory technology into the mainstream method for urban waste management. After more than 30 years of development, China has built the world's largest municipal waste incineration system, with a processing capacity exceeding 1.12 million tons per day in 2024, supported by leading-edge technology.

This book presents a comprehensive overview of the waste incineration industry in China, covering policies and standards, technological innovation, and future trends. It highlights best practices and lessons learned, offering practical guidance for developing countries facing similar waste management challenges, while contributing "Chinese wisdom" and "Chinese solutions" to global environmental governance and low-carbon development.

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Foreword

This volume provides a systematic exposition of China's WtE policy landscape, technological advancements, and future trajectories. It distills the sector's most impactful practical achievements and, through the exemplary practices of industry leaders like SUS ENVIRONMENT, presents valuable "Chinese wisdom" and "Chinese solutions" for advancing global sustainable waste management and low-carbon development.

China's experience offers a compelling case study of how coherent public policy, industrial capability, and technological innovation can converge to address the complex challenges of rapid urban growth. Over the past decades, the country has moved from fragmented disposal practices to an increasingly integrated system in which waste-to-energy plays a central and strategic role. As China's urbanization rate surpasses 65%, its cities now generate over 250 million tonnes of municipal solid waste (MSW) annually, presenting a pressing environmental imperative. Waste-to-energy (WtE) has emerged as the predominant approach, leveraging its distinct advantages in volume reduction, energy recovery, and environmentally sound treatment to become the bedrock of China's modern waste management framework.

Through more than three decades of dedicated development, China has established the world's most extensive WtE infrastructure, with daily processing capacity exceeding 1.12 million tonnes. This extraordinary expansion is underpinned by a robust triad of policy frameworks, technological innovation, and operational expertise and efficiency.

A comprehensive scheme of regulations and standards governs the entire project lifecycle—from site selection and engineering design to operational oversight and emissions control. Continuously refined and supported by targeted incentives, this framework has been instrumental in guiding the industry's high-quality development on a scale.

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Technologically, China has achieved remarkable breakthroughs with the independent development of large-scale mechanical grate incinerators capable of processing 1200 tonnes per day, specifically engineered for high-moisture, low-calorific waste. The establishment of an integrated technological chain-featuring high-efficiency power generation, ultra-low flue gas emissions, near-zero leachate discharge and comprehensive by-product utilization-demonstrates the sector's advanced capabilities. Particularly noteworthy, China's sophisticated leachate treatment system has yielded valuable insights applicable to waste management challenges across Southeast Asia and other regions.

With over 1000 WtE facilities commissioned nationwide, China has accumulated substantial engineering expertise in managing complex operational conditions, optimizing construction efficiency, and pioneering eco-industrial park models for synergistic treatment of municipal solid waste streams.

Dr. Long Jisheng, the chief editor (of this publication), has been pivotal in this sector's evolution. Following extensive international practice, he founded SUS ENVIRONMENT Co., Ltd. in 2008. Under his visionary leadership, the team has pioneered next-generation mechanical grate incinerator technology, advanced combustion control technologies, and cutting-edge emission purification processes, achieving complete technological independence and ending reliance on imported solutions. Through its groundbreaking design paradigms centered on "energy-efficiency" and "emission control", SUS ENVIRONMENT has been instrumental in transforming public perception from "Not In My Backyard (NIMBY)" to "Please In My Backyard (PIMBY)".

China's journey reflects the importance of long-term policy consistency, continuous technological upgrading, and transparent environmental standards in achieving both climate mitigation and resource efficiency objectives. As the global waste and resource management sectors seek pathways consistent with climate goals and circular economy ambitions, constructive international dialogue and knowledge exchange remain essential. It is my hope that this publication will contribute meaningfully to that dialogue and foster further collaboration between China and the global waste management community in advancing sustainable, low-carbon solutions for the future.

James Law
President
International Solid Waste Association (ISWA)
January 2026

Preface

As a core pillar of urban solid waste management, municipal solid waste incineration achieves waste reduction, resource utilization, and harmless disposal while enabling efficient energy recovery. It serves as a critical pathway for advancing the circular economy and achieving China's carbon peak and neutrality targets. Though China's waste-to-energy (WtE) industry emerged relatively late, three decades of vigorous development have propelled the sector from early technology introduction and assimilation to a new era of independent innovation and global leadership, establishing a distinctive high-quality development paradigm for the industry.

The evolution of China's WtE technology can be divided into four distinct developmental stages. The exploratory stage (late 1980s–2000) began with the commissioning of Shenzhen's first modern WtE plant and key national research and development (R&D) projects under China's Eighth Five-Year Plan. This period initiated domestic technological and equipment R&D, achieving a pivotal breakthrough from full import dependence to partial localization of core equipment. The growth stage (2001–2005) marked the gradual improvement of policy and standard frameworks alongside increasingly stringent environmental requirements. Domestically manufactured grate incinerators were widely promoted and applied, while the integrated flue gas purification process consisting of semi-dry deacidification, activated carbon injection and bag filter became the mainstream technical solution. Synchronous progress was also made in leachate and fly ash treatment technologies, with a large number of modern WtE plants completed and commissioned. Driven by the national ecological civilization strategy, the industry entered a rapid development stage from 2006 to 2020, marking its golden development period. Large-scale mechanical grate incinerators with independent intellectual property rights, featuring a single-unit capacity of up to 850 tonnes per day, dominated the domestic market. Cutting-edge technologies including ultra-low flue gas emission control, medium- and high-parameter power generation, and intelligent system control achieved continuous iterative upgrading. China has since ranked first globally in

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total municipal solid waste treatment capacity, delivering a host of world-class benchmark engineering projects. Since 2021, the industry has entered a steady and innovation-driven development stage. Against a backdrop of slowing market expansion, the industry focus has shifted toward lean operation, cost reduction and efficiency enhancement. Current technological research prioritizes large-scale unit design, high-efficiency operation, intelligent management, and low-carbon transformation, while domestic enterprises are actively expanding overseas business under the Belt and Road Initiative.

Throughout this development trajectory, China's indigenous technological innovation has attained globally recognized achievements. In core equipment research and application, leading enterprises including SUS ENVIRONMENT, SANFENG ENVIRONMENT and EVERBRIGHT ENVIRONMENT have independently developed and widely applied super-large mechanical grate incinerators. These units are specially optimized to suit the characteristics of China's municipal solid waste: high moisture content, low calorific value and complex composition. These incinerators reach a maximum single-unit processing capacity of 1200 tonne/day, meeting internationally advanced standards in waste adaptability, combustion efficiency and core component service life.

In terms of high-efficiency energy utilization, the domestic WtE industry has overcome the technical bottleneck of high-temperature corrosion in high-parameter waste heat boilers. Mainstream steam operating parameters have been progressively upgraded from medium-temperature and medium-pressure (4.0 MPa/400 °C), to medium-temperature and sub-high-pressure (6.5 MPa/450 °C), and further to medium-temperature and super-high-pressure (13.5 MPa/450 °C/485 °C). Combined with advanced technologies such as external dehumidification coupled with main steam reheating (MSR), these upgrades have raised the power generation efficiency of WtE plants from the traditional 20%–25% to over 30%, representing a landmark leap in industrial energy conversion performance.

In advanced pollution control, China has established the world's most stringent flue gas emission standards for WtE plants and pioneered a comprehensive ultra-low emission process system: selective non-catalytic reduction + semi-dry scrubber + dry sorbent injection + activated carbon injection + bag filter + selective catalytic reduction + wet scrubber. This integrated technical system ensures that emissions of particulate matter, sulfur dioxide, nitrogen oxides and other key pollutants are consistently maintained below regulatory limits.

Regarding by-product utilization and co-processing, China's WtE industry has formed a complete set of mature resource recovery technologies. These include fly ash treatment technologies such as water washing desalination coupled with cement kiln co-processing, low-temperature thermal decomposition coupled with water washing treatment, and high-temperature melting, as well as high-efficiency slag sorting technologies that realize metal recovery and the reuse of remaining tailings as construction raw materials. Beyond by-product recycling, innovative multi-source solid waste co-disposal modes have been developed, covering dried sludge, kitchen waste, and clinical waste co-processing. These practices have effectively improved facility utilization efficiency and strengthened the overall capacity of urban solid waste integrated management.

In the field of digitalization and intelligent operation, China's WtE industry has taken the lead in applying artificial intelligence (AI), machine vision, digital twins and other emerging technologies to incineration process control. Independently developed AI-based intelligent combustion optimization systems have enabled a fundamental shift from empirical manual regulation to data-driven smart combustion, greatly improving the operational stability, economic efficiency and environmental performance of WtE plants.

This book systematically establishes the complete knowledge framework and technical roadmap for municipal solid waste incineration power generation in China, covering policy and standard systems, technical principles, equipment systems, innovative engineering practices, operational management, and intelligent low-carbon development. It elaborates on full-process core technologies including waste receiving and storage, grate incineration, waste heat recovery, flue gas purification, leachate treatment, and ash-slag disposal. Meanwhile, the book highlights China's independent technological innovations and representative engineering practices in frontier fields, including large-scale grate equipment, high-parameter power generation, ultra-low emission control, intelligent operation, multi-waste collaborative treatment, and carbon capture, utilization and storage.

This book was authored by Jisheng Long, Xuejun Jiao, Li Bai, Jianping Li, Hailiang Du, and Yiru Huang, with valuable contributions from Yacheng Liu, Yang Cao, Zhaohui An, Yantao Wang, Yue Gong, Qianqian Yao, Honglei Hu, Chaojun Wen, Jingying Huang, Dekun Yang, Lu Chen, Jianguo Han, Jian Liu, Shujia Liu, Meilin Zhu, Di Wang, Haowen Yan, Qibin Yuan, Chongzhen Fu, Yilian Wu, Zhangfeng Hao, Yang Yang, Po Zhang, Dawei Qian, Liangliang Yang, Yunfeng Lao, Yuling Wen, Rui Gong, Haocheng Zhu, Fali Hu, Yong Dai, Bin Li, Yiyang Zhang, Jiachen Hu, Jidong Liu, Bei Li, Zhiwei Hu, Xiaoming Wang, Yifeng Chen, Youdong Wang, Yue Wang, Fei An, Shudong He, Zhiwei Liu, Chengxu Feng, Wangxiang Chen, Ting Yao, and Danian Ruan. The authors sincerely thank all contributors for their dedication and rigorous efforts in the compilation of this book. We hope this work can serve as a valuable reference for advancing global municipal solid waste incineration power generation technologies and promoting the green, low-carbon and intelligent development of the industry. Due to the limitations of the authors' knowledge and experience, inadvertent omissions and deficiencies may remain in the text. All valuable comments and corrections from readers are warmly welcomed.

Contents

Chapter 1

Policy and Standard System for Waste-to-Energy of China

The waste-to-energy (WtE) industry of China began in the late 1980s, gradually progressing through exploration, initial development, rapid development, and stable development phases. Over the past three decades of WtE development, policy support, demand drivers, and technological advantages have emerged as the three most critical driving factors. The introduction of a series of policies has mobilized local governments and enterprises, effectively driving the development of the full industry chain for waste incineration. Concurrently, China has actively advanced standardization efforts to regulate technical standards, enhance technical exchange and collaboration, and improve industrial technological capabilities and innovation capacity by integrating it into industrial policies. It is precisely this series of promulgated laws, regulations, policies, and standards that has effectively driven the rapid and high-quality development of the WtE industry.

1.1 Key Policy Framework for Solid Waste Treatment Industry of China

The municipal solid waste (MSW) treatment industry of China has established a systematic and well-developed management system and policy framework, forming a governance pattern characterized by central coordination, local implementation, and multi-department collaboration. The policy system covers multiple dimensions, including comprehensive planning, fiscal and tax support, and technical standards, comprehensively utilizing economic incentives and market mechanisms to promote the construction of treatment facilities and technological innovation. This has effectively advanced waste treatment towards reduction, resource recovery, and harmlessness, creating a favorable development environment for modern treatment methods such as WtE.

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1.1.1 Management System for MSW Treatment Industry of China

China implements a five-tier government management system comprising the State Council—province and municipality directly under the Central Government—prefecture-level city—county, city—township, and town. In waste management administration, the State Council, provincial, and county and city governments play crucial roles. Specifically, ministries under the State Council are primarily responsible for formulating regulations, policies, and standards. Provincial governments mainly oversee policy implementation (some provinces also establish provincial-level policy standards). County and city governments serve as executive entities and are responsible for planning and constructing waste collection and disposal facilities, as well as fee collection and payment.

The administrative departments of the waste management industry primarily involve the Ministry of Housing and Urban–Rural Development (MOHURD), the Ministry of Ecology and Environment (MEE), the National Development and Reform Commission (NDRC), and the Ministry of Finance (MOF) at both national and local levels. The main responsibilities of each department are shown in figure 1.1. MOHURD primarily guides the technical direction of industry, and issues industry standards, construction standards, and technical specifications. MEE focuses on formulating pollutant emission policies and supervising pollutant emissions. NDRC is responsible for releasing industrial policies (such as concession operations and electricity pricing), formulating plans and policies, and managing investment approvals and supervision. MOF mainly develops fiscal policies, funding arrangements, fiscal subsidies, and incentives. Additionally, multiple national and industry departments form the National Patriotic Health Campaign Committee, an advisory and coordinating organization within the State Council, tasked with unified leadership and coordination of patriotic health-related work, and directing nationwide concerted actions on waste management issues. This committee has issued a series of early waste management policies, such as Notice on the report of handling municipal waste to improve environmental sanitation (State Council General Office Document [1986] No. 57) and Notice on several suggestions regarding solving domestic waste problems of China (State Council Document [1992] No. 39), which have propelled the development of WtE. Furthermore, the advancement of WtE has also relied on joint efforts by industry associations such as the China Association of Urban Environmental Sanitation, the China Association of Environmental Protection Industry, and the China Association of Circular Economy. These associations assist government departments in conducting industry research and information collection, facilitating communication among industry stakeholders, standardizing industry operations, establishing standards, building industry exchange platforms, and uniting various industry players to promote the high-quality development of the environmental sanitation sector of China.

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