

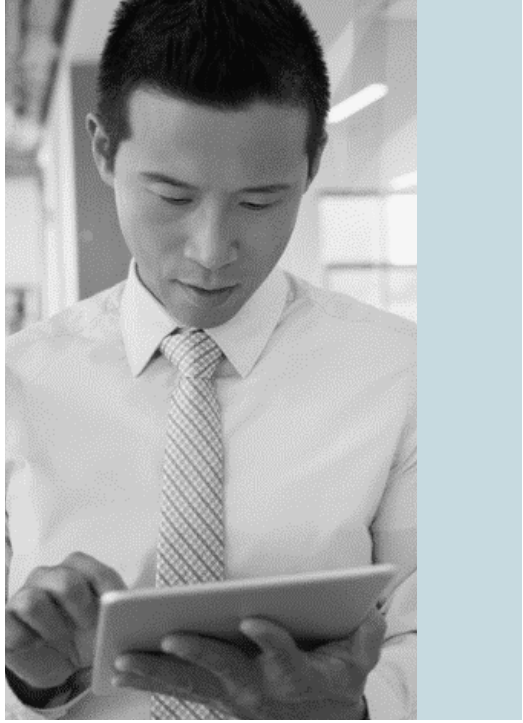


Sustainability Insights

From Waste To Watts

Overview of global waste-to-energy developments

Jan. 23, 2025

S&P Global
Ratings

This report does not constitute a rating action

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Key Takeaways

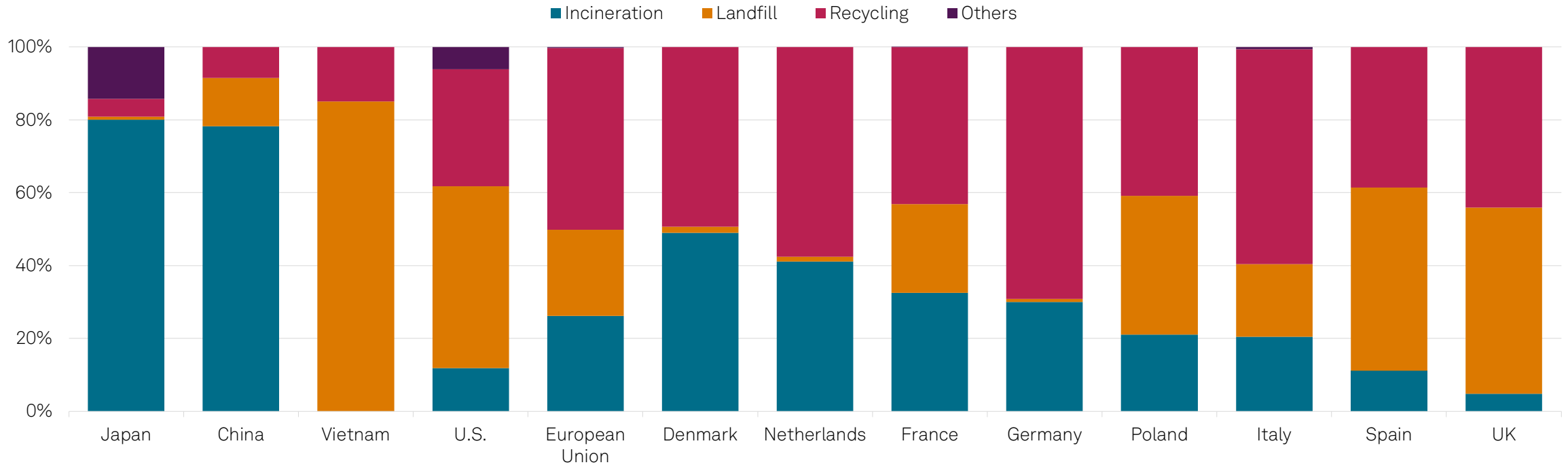
- Global adoption of waste-to-energy (WtE) technology varies by policy and regulatory support. China, Japan, and Northern Europe (excl. UK) are leaders in waste incineration, whereas Southeast Asia, and to a certain extent Southern Europe, relies on cheaper landfilling due to inadequate waste management systems. These regions represent the next growth markets.
- WtE generally has a lower carbon footprint than landfills, especially if it is part of a broader waste management approach. The carbon footprint of WtE can vary significantly depending on the waste feedstock composition. China's WtE power generation has higher GHG emission intensity than coal power, but its contribution to national power supply is small.
- WtE revenue sources are similar in most countries, mostly from waste treatment fee and electricity sales. Contract structures vary, with China using a 25 to 40-year build-operate-transfer model, whereas the U.S. and Europe favor shorter and extendable multiyear contracts.
- Markets are fragmented in most countries. China is notable for the presence of state-owned entities, supported by favorable financing from its banking sector.
- Credit profiles of WtE operators are shifting. In China, cash flows are improving on declining investments, but reduced subsidy support for new projects may mean lost revenues.
- European operators with higher growth plans funded by debt may see leverage increase with declining power prices, in the next couple of years.

Global WtE Overview

Globally, Implementation Of WtE Is Uneven

China and Japan have the highest incineration rates in Asia, whereas Europe has varied waste treatment practices.

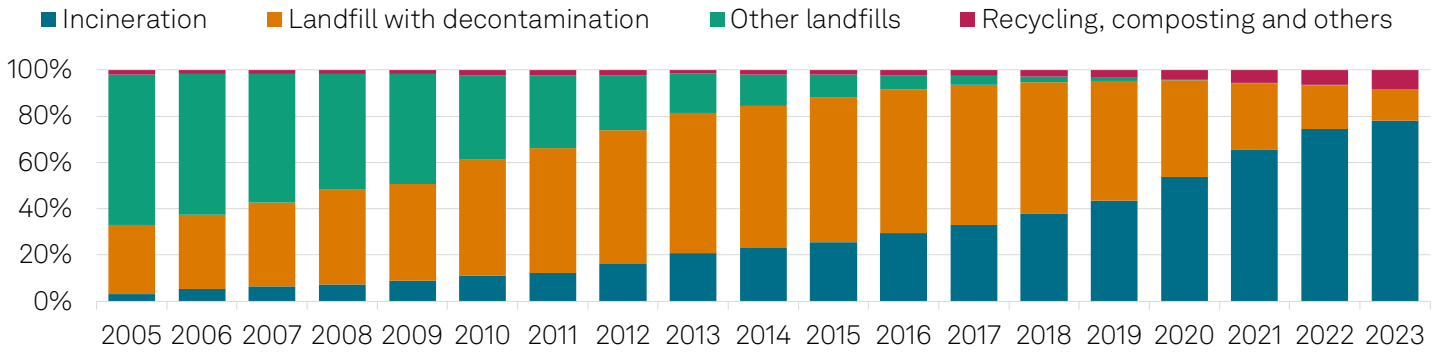
Overview of municipal waste treatment method by select countries*



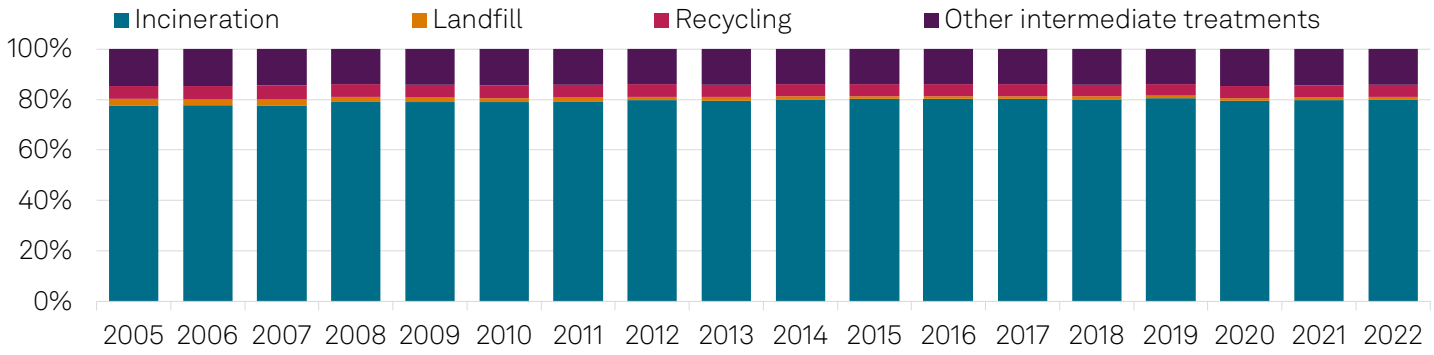
*Data is as of 2023 for China, 2022 for Japan, Vietnam, EU and selected countries in the EU, and 2018 for the U.S. Sources: Japan Ministry of the Environment, China Urban-Rural Statistical Yearbook, Vietnam MONRE, EPA, Eurostat, S&P Global Ratings.

WtE Adoption Is Based On Different Factors

China taking strides in incineration, with an eye on recycling next



Japan has historically maintained a high incineration ratio

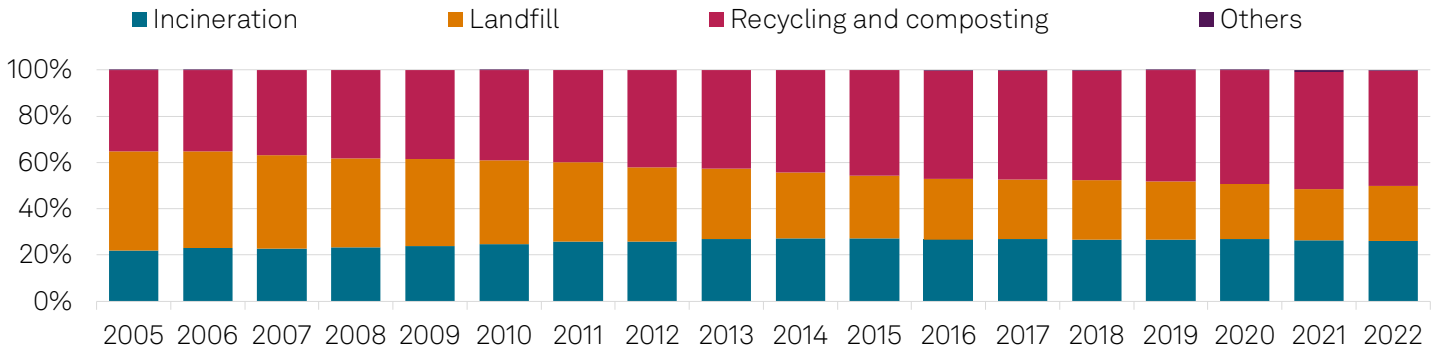


Sources: China Urban-Rural Statistical Yearbook, Japan Ministry of the Environment, S&P Global Ratings.

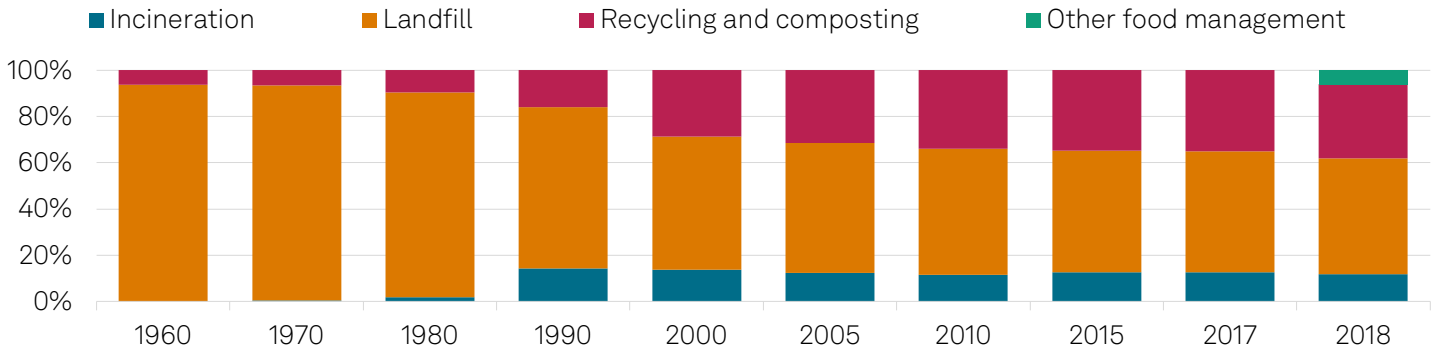
- China and Japan prioritize waste incineration over landfilling due to advantages such as reduced land use and lower land and water pollution.
- Japan enforces strict waste-sorting policies, enhancing collection and transportation efficiency to treatment facilities.
- China introduced national waste-sorting guidelines in 2019, aiming to improve downstream recycling. Full implementation may take several more years.

WtE Adoption Is Based On Different Factors

European regulation prioritizes waste reduction and recycling



U.S. waste management is still dominated by landfilling



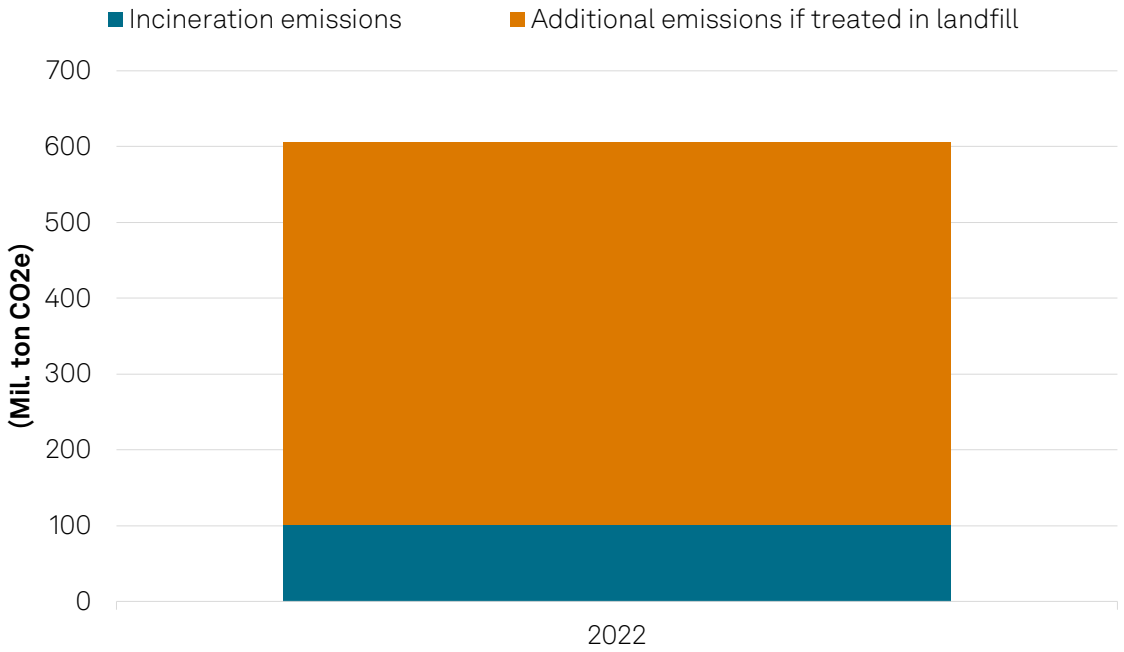
Sources: EPA, Eurostat, S&P Global Ratings.

- European legislation sets landfilling limits and recycling targets for 2025, 2030, and 2035. Progress varies widely by country.
- In contrast, landfill waste still predominates in the U.S., given cost advantages over other methods and less policy support for WtE. WtE is more prevalent in areas with high population density and scarce land availability.

WtE Can Also Fit Into Decarbonization Goals

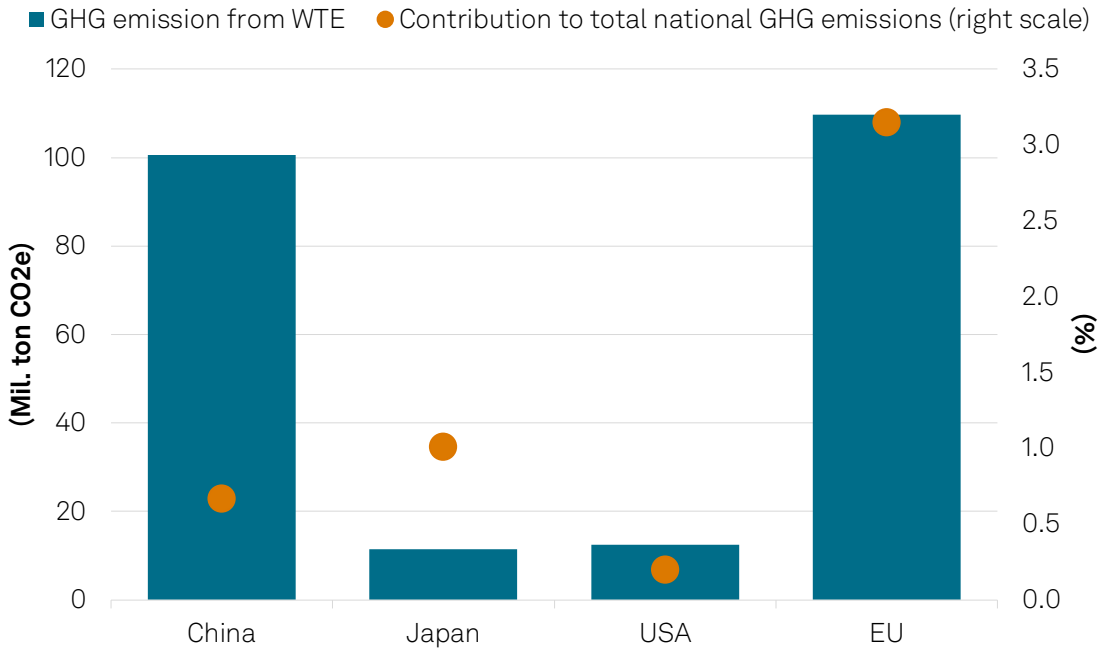
WtE can help reduce emissions on a net basis mainly by replacing landfills, which emit methane, a more potent GHG. Modern incinerator tech, e.g. China's moving-grate system, enables self-sustaining waste combustion, requiring minimal diesel for ignition and no extra fuel as feedstock in the burners.

WtE can have lower impact than unmitigated landfill*



*Data reflects Scope 1 emissions as in China's case. Sources: China Ministry of Ecology and Environment, S&P Global Ratings.

And it contributes very little to national GHG emissions*

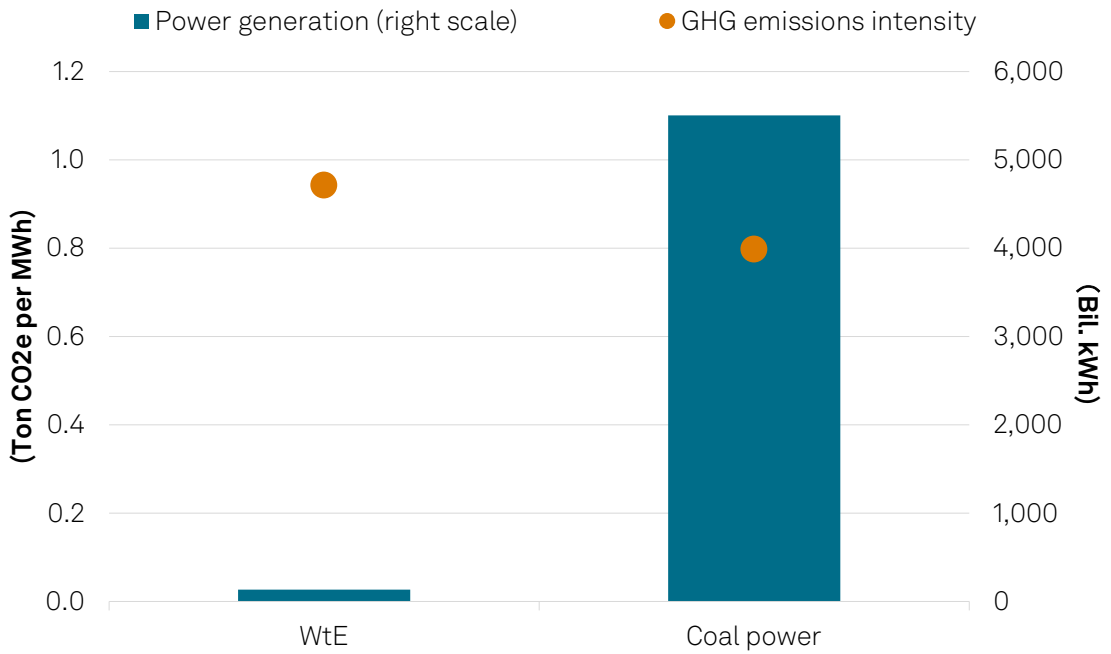


*Data is as of 2022 and reflects Scope 1 emissions. Japan and EU emissions figures include all waste management methods (such as landfills) and hence may overstate emissions from WtE sector alone. GHG--Greenhouse gas. Sources: EPA, Eurostat, Emissions Database for Global Atmospheric Research, Japan Ministry of Environment, China Ministry of Ecology and Environment, S&P Global.

WtE Also Fits Into Decarbonization Goals (Cont'd)

WtE are gross emitters mostly due to presence of fossil content in waste, such as plastic. However, their contribution to national power supply remains minimal. We expect carbon capture to be the next major step in reducing emissions.

WtE in China has high GHG emissions but low generation*



*WtE emission intensity is 2022 figure, based on Ministry of Ecology and Environment's report <2022生活垃圾焚烧发电行业绿色发展水平评估报告>; coal power emissions is 2023 figure based on the ministry's national carbon quota allocation plan. Data are scope 1 emissions. Sources: China Ministry of Ecology and Environment, Wind, S&P Global Ratings.

Emissions standards for WtE vary; EU the most stringent

	Unit	China	USA (>250t/d)	USA (30-250t/d)	EU
Dust particle	mg/Nm3	20	14	17	10
HCl	mg/Nm3	50	29	29	10
Sulfur dioxide (SO2)	mg/Nm3	80	61	61	50
Nitrogen monoxide and dioxide	mg/Nm3	250	264	220	200
Carbon monoxide (CO)*	mg/Nm3	80	/	/	50
Mercury	mg/Nm3	0.05	0.036	0.057	0.05
Dioxin	ng TEQ/m3	0.1			0.1
	mg/Nm3		9.3	9.3	

*Carbon monoxide emission standard for USA varies for different combustion technologies, ranging from 48-144 mf/Nm3. Sources: Federal Register, China Ministry of Environmental Protection, EU Directive on Industrial Emissions.

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Key Features Of WtE Operating Models In Different Regions

	China	Germany*	USA	Japan
Contract structure	Build-operate-transfer (BOT) model, with concession period of 25-40 years	• Owner of WtE plant, with multi-year (<15 years) contract with municipalities; subject to extension • Operation and maintenance (O&M) service provider to government-owned WtE plant	• Owner of WtE plant, with multi-year contracts with municipalities; subject to extension; or • O&M service provider to government-owned WtE plant	• Design-build-operate (DBO) model contract with local government • Engineering, procurement, construction & operation (EPC+O) service to local government-owned WtE plant
Revenue source	• Waste treatment fee • Electricity sales	**Owner model** • Waste treatment fee • Electricity, heat, and steam sales **Operator model** • Annual service fee	**Owner model** • Waste treatment fee • Electricity and steam sales • Capacity charges in power market **Operator model** • Annual service fee	**DBO model** • Waste treatment fee • Electricity and heat sales **EPC+O model** • Construction revenue • Operation service fee
Is pay-as-you-throw implemented?	Yes	Yes	No, primarily indirectly via taxes or fixed fees	Yes

*We choose Germany as a representative for European market, given generally similar operating models in the region. Source: S&P Global Ratings.

Key Features Of WtE Operating Models In Different Regions (Cont'd)

	China	Germany*	USA	Japan
Waste treatment fee adjustment cycle	Most BOT contracts stipulate fee adjustment cycles every 1-3 years; some do not mention frequency. Adjustment considers cost inflation, tariff changes, and other policy changes. Requires negotiation with government and may take several months.	Subject to annual adjustments, based on market supply demand dynamics.	Subject to annual adjustments, in line with consumer price index.	Most contracts dictate price fluctuation risk should be ultimately borne by the local governments; negotiated price revisions is allowed up to once a year
WtE electricity tariff policy	**Regulated pricing** • Projects commissioned before end-2021: feed-in tariff of RMB0.65/kwh • Projects commissioned after 2021: fixed tariff determined by competitive bidding	**Merchant sales** • Selling to utilities at prevailing market rates	**Merchant sales** • Selling to utilities or industrial offtakers at contracted rates or prevailing market rates in regional markets	**Merchant sales** • Selling to utilities at prevailing market rates • Certified biomass power generation is subject to the FIT (Feed-in tariff) or FIP (Feed-in premium) schemes

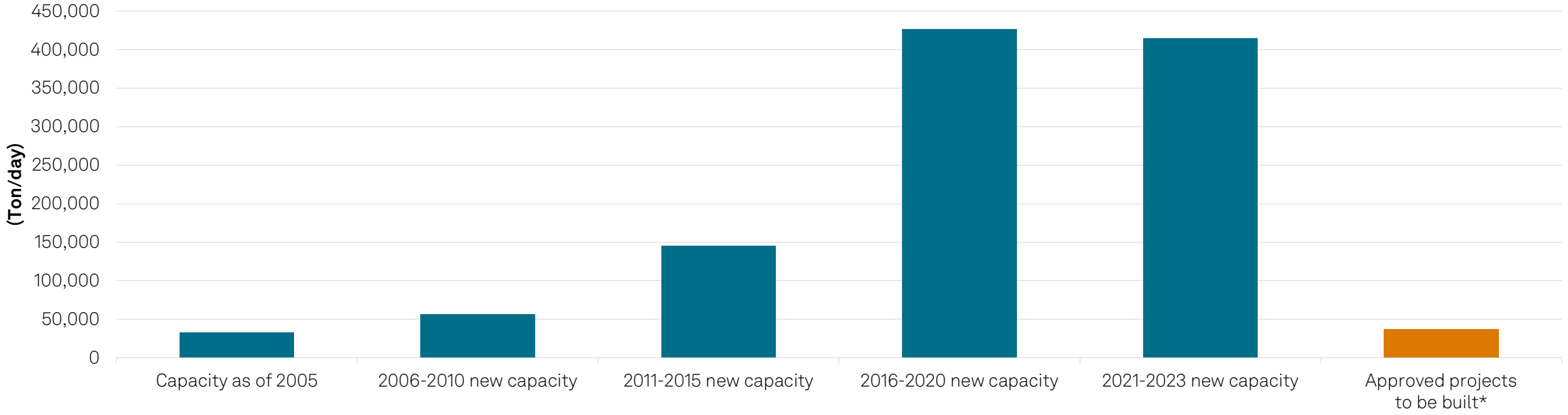
*We choose Germany as a representative for European market, given generally similar operating models in the region. Source: S&P Global Ratings.

Regional Snapshots

China | The Largest WtE Sector In The World

- China first introduced WtE targets in its national Five-Year Plan for 2006-2010, setting a 35% incineration rate for eastern cities.
- Capacity growth accelerated as targets increased, including a zero landfilling by 2020 goal for selected large cities.
- By 2023, total capacity reached 1.08 million ton/day.

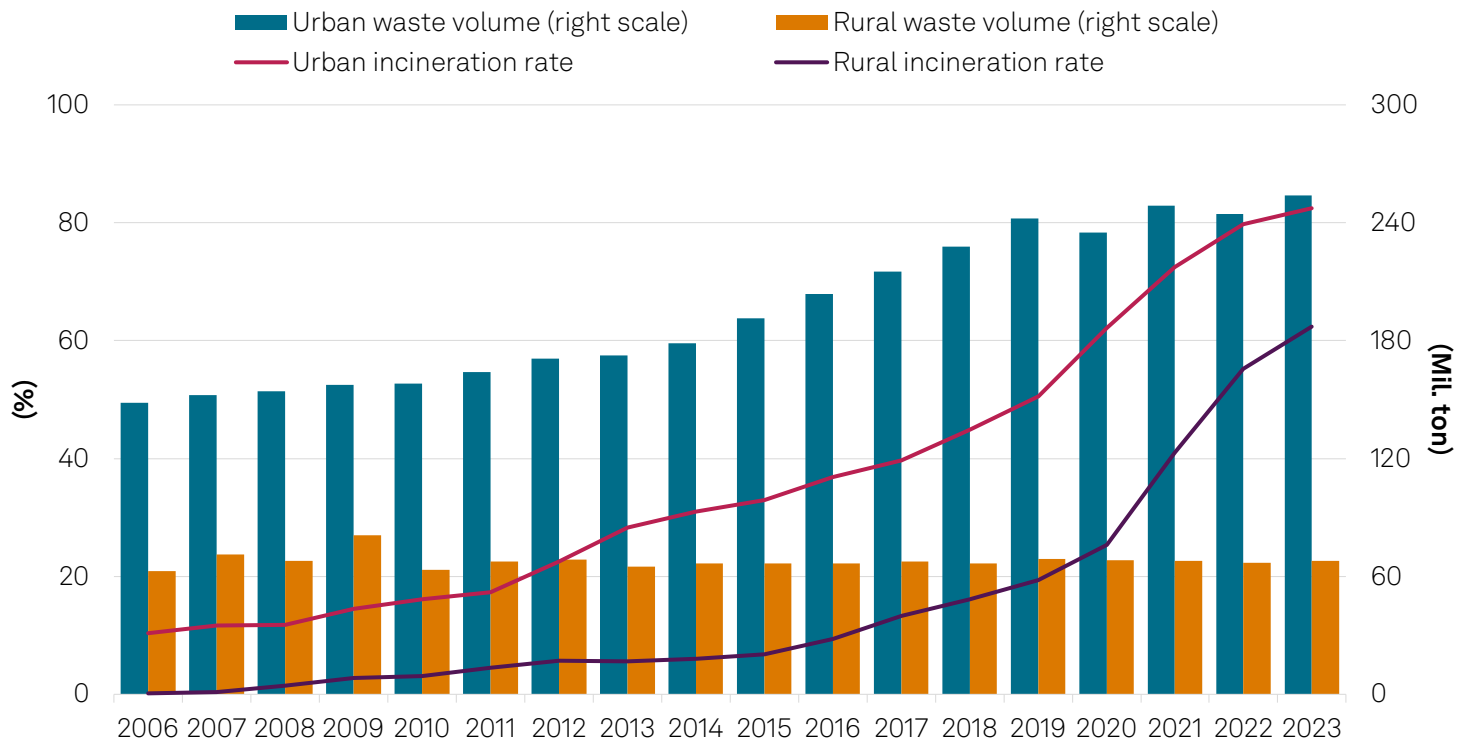
China's WtE capacity is coming off an investment peak



*Data is as of mid-2024, based on projects approved in 2023 and first half of 2024. Sources: China Ministry of Ecology and Environment, China Urban-Rural Statistical Yearbook, S&P Global Ratings.

China | Rural Projects Will Drive Growth As Urban Market Matures

Waste incineration rate in rural areas lags urban areas



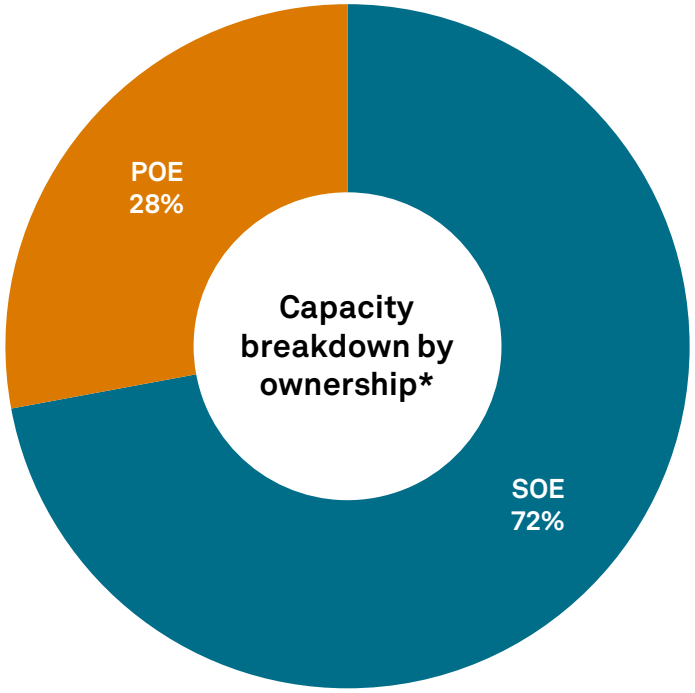
Sources: China Ministry of Ecology and Environment, China Urban-Rural Statistical Yearbook, S&P Global Ratings.

- National policy is shifting to promote WtE growth in rural areas, where 35% of waste still goes to landfills.
- Achieving a 100% rural incineration rate would require an additional 65,000 tons/day of capacity, entailing roughly RMB55 billion in investment.
- Project risks may be higher in these areas. Risks include unstable waste volumes, complex waste collection chain, lack of scalability, and lower heat content of waste.
- Weak fiscal capacity of local rural governments may also mean low treatment fees or delayed payments.

China | State-owned Entities Are Dominant Players In A Fragmented Market

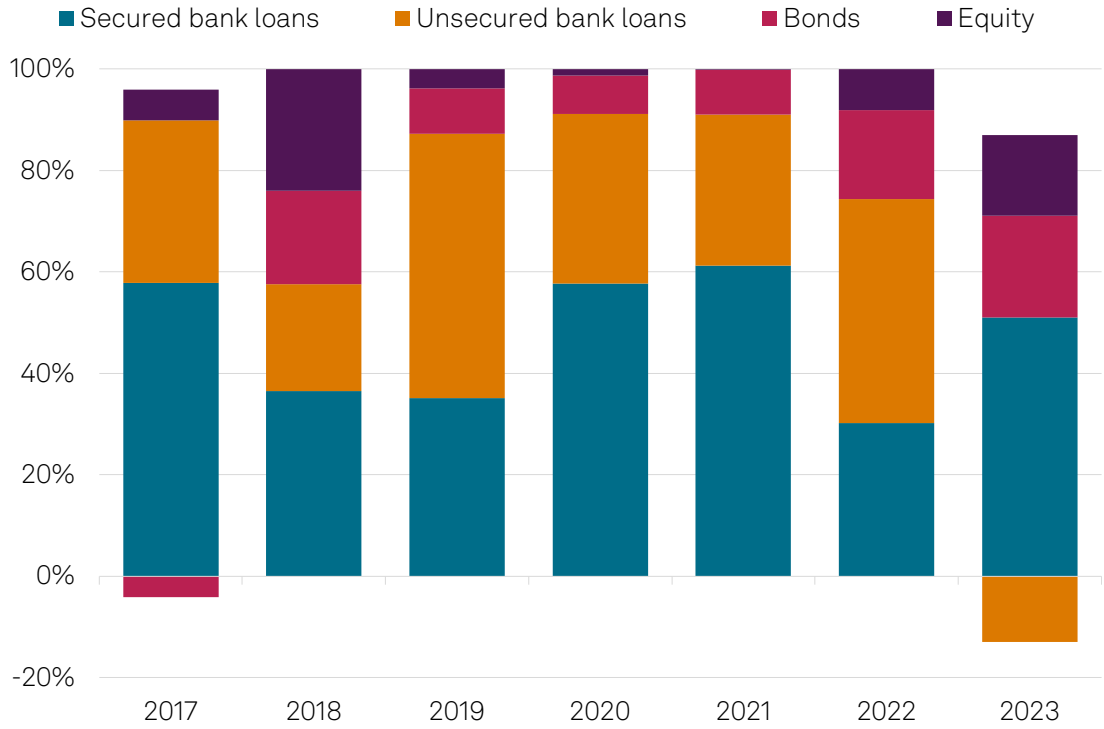
Funding is backed by bank loans, largely from state-owned banks

SOEs are key players in the market



*Capacity breakdown is based on capacity of top 25 listed domestic WtE operators as of 2023, which in aggregate account for 64% of total national capacity. SOE--State-owned entities. POE--Privately-owned entities.
Sources: Wind, Company annual reports, S&P Global Ratings.

Secured bank loans are a staple funding source*



*Breakdown of annual net financing for WtE operators, calculated from sample of top 18 listed domestic WtE operators whose WtE revenues account for more than 50% of total revenues.
Sources: Wind, Company annual reports, S&P Global Ratings.

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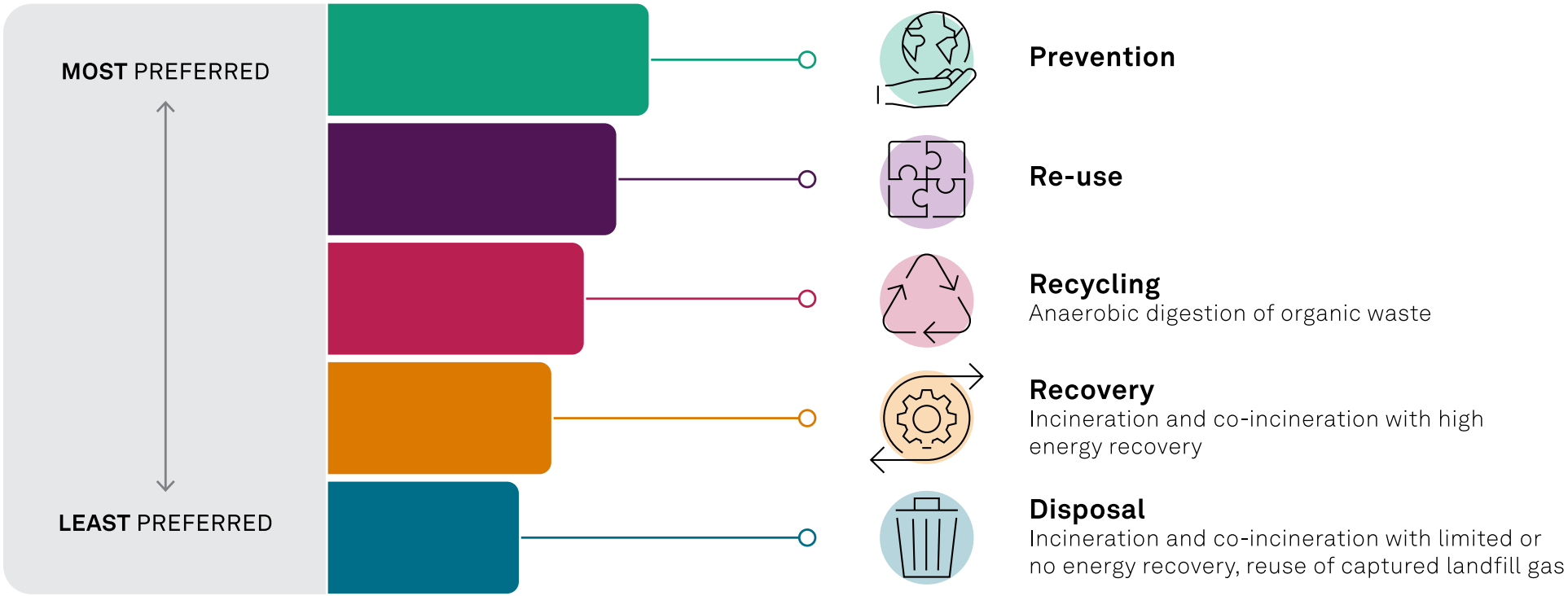
Europe | The Overarching Principle Of EU Policies Is The Waste Hierarchy

WtE processes are positioned at the bottom of the waste hierarchy



Europe | Key Characteristics Of The Western European WtE Market

Market conditions differ across Europe

- EU law set a target of maximum landfilling at 10% of the total municipal waste by 2035. Some countries are at or below that target (e.g. Germany) while most are still far from it, with large differences.
- Incineration and WtE capacity is uneven. Highest per capita capacity is in northern Europe; southern states (e.g. Spain) more reliant on landfill.
- Germany is one of the most advanced circular economies in Western Europe.

Barriers to entry are high

- EU regulation prioritizes waste reduction and recycling, so we expect new build WtE capacity to be allowed only when the risk of stranded asset is minimal.
- As well as permitting and technological know-how, large startup capex (we observe €0,75-1 million per kton of new treatment capacity) and relatively long payback periods (5-10 years) help incumbents and big players.
- Another key hurdle is the mostly local and public or private/public nature of the municipal waste market.

WtE part of decarbonization strategies

- When first-choice strategies reach their limits, including recycling, WtE and bioenergy technologies become the more environmental-friendly option to landfilling from a GHG emissions perspective.
- E.g. Converting organic waste into biogas can provide a renewable source of energy for heating and power generation, reducing reliance on fossil fuels.
- Landfilling (with or without CH4 capture) remains the least preferred option in waste management strategies to address GHG emissions reduction.

Future Trends
In China And Europe

China | Tariff Subsidies Are Fading As Government Encourages Competition

This follows the same path as tariffs for renewables

Before 2006

- Tariff is determined by local government pricing bureau.
- Policy dictates that WtE project return should be ensured through adequate treatment fee.

2006 Fixed subsidy

- For projects approved starting in 2006, tariff = **local province's coal power benchmark tariff + fixed subsidy of RMB 0.25/kWh**
- **Subsidy is paid** for 15 years from start of operation.
- No change to older projects.

2012 Feed-in tariff

- For all projects approved starting in 2006, tariff is split in two parts: For generation up to **280kWh** per ton of waste, tariff is **RMB0.65/kWh**. For generation beyond that, tariff is local coal power benchmark tariff.
- **RMB0.65/kWh** comprises local coal power benchmark tariff + RMB0.1/kWh of subsidy from grid company + balance from central government subsidy fund.

2020/2021 Competitive tariff

- Projects commissioned by end-2021 will operate under the 2012 feed-in tariff policy.
- Tariffs for newer projects will be set through **competitive bidding**, with recent successful bids ranging from RMB0.52/kWh to RMB0.63/kWh.
- **Subsidies on all projects will be paid** for a maximum of 15 operating years or 82,500 operating hours.

China | WtE Projects Have Limited Channels To Recoup Loss Of Subsidies

Source 1: Higher treatment fees

- Based on average treatment fee of RMB72 for projects approved in 2018-2020, fee will have to increase by 40%-120% to cover lost subsidies, a big burden for smaller local governments.
- Calculation as follows: For projects with feed-in tariff of RMB0.65/kWh, central government subsidy ranges from RMB0.10/kWh-RMB0.30/kWh. Assuming net generation of 280kWh per ton of waste, this is equivalent to RMB28-RMB84 per ton of treatment fee.

Source 2: Green power, carbon trade

- While WtE projects are eligible for green certificate trading, prices in China are very low due to oversupply. 2024 average green certificate price is at RMB0.01/kwh.
- WtE is currently not eligible for the Certified Emission Reduction (CCER) program, China's voluntary carbon market. Should it be approved, at emissions reduction of about 0.30 tCO2e per ton of waste treated, and carbon price of RMB100 per ton, it could mean additional revenue of RMB30 per ton of waste.

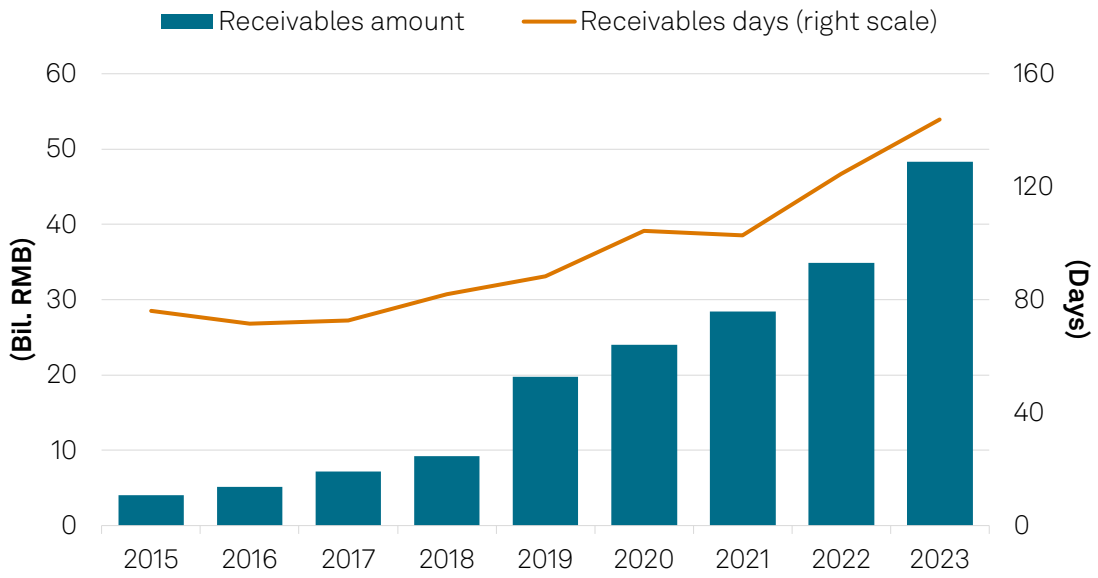
Source 3: Upstream expansion

- Upstream business includes waste collection, sorting, transporting, as well as cleaning services.
- While it has lower barriers to entry and capital intensity, margins are also lower than WtE projects.
- Lack of regulatory protection leads to intense competition and likely narrowing margins.

China | Debt Growth For WtE Operators To Slow Despite Receivables Drag

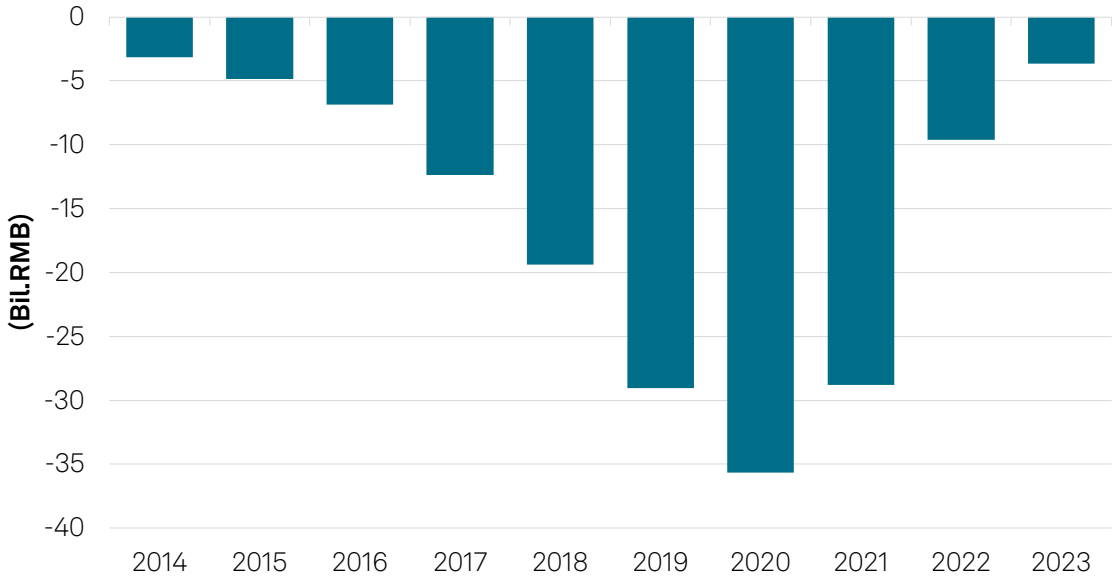
- Cash collection cycle for tariff subsidies and treatment fees is lengthening. This is mainly due to a funding shortfall in the central government subsidy fund and the declining fiscal conditions of local governments amid weak economic growth.
- Still, we anticipate free cash flow to improve due to declining capital expenditures. There are fewer projects in the pipeline, and capacity expansion on existing projects requires less investment due to main infrastructure already in place.

Receivables drag shows few signs of easing*



*Based on sample of top 18 listed WtE operators whose WtE revenues account for more than 50% of total revenues.
Sources: Wind, Company annual reports, S&P Global Ratings.

Free cash flow has improved since spending peak in 2020§



§Based on sample of top 18 listed WtE operators whose WtE revenues account for more than 50% of total revenues.
Sources: Wind, Company annual reports, S&P Global Ratings.

Europe | Future Trends For The Western European Market

WtE to bridge the recycling gap

- According to the waste hierarchy principle, the EU favors recycling and re-use over WtE.
- However, WtE remains a viable option in more landfill-dependent countries while recycling rates pick up.
- We expect mild growth opportunities in the more advanced circular economies (e.g. Germany) and more sustained momentum in landfill-dependent countries (e.g. Italy, Spain).
- Given drawbacks of the recycling process for some materials, while WtE capacity may decrease in the long-run, some will remain necessary.

Large investments may imply reduced rating headroom

- While difficult to quantify, future investment needs in waste treatment infrastructure in the EU (both for new capacity and revamping) are very large and may amount to as high as €30 billion-€35 billion*.
- While a business mix weighted toward WtE should sustain higher EBITDA margins and better returns on capital compared with, say, recycling, it may lead to somewhat weakening cash flow generation for our rated issuers.
- In addition, WtE revenues tend to be rather volatile, further constraining balance sheets.

Small-scale consolidation is likely

- There has been a great number of players in the municipal waste treatment market, given its local nature.
- Consolidation is likely between smaller players as the market is already fairly concentrated.
- In Spain and France, the private treatment market is significantly concentrated. The two largest players control about two thirds of the market. In Germany, the top two players account for about half of the private waste treatment market. In Italy, fragmentation is even higher.

*According to a study prepared for the European Commission in 2019, assuming EU's landfilling and recycling targets to 2035 are reached.

WtE Sector Ratings Snapshots

China | Beijing Environment Sanitation Engineering Group

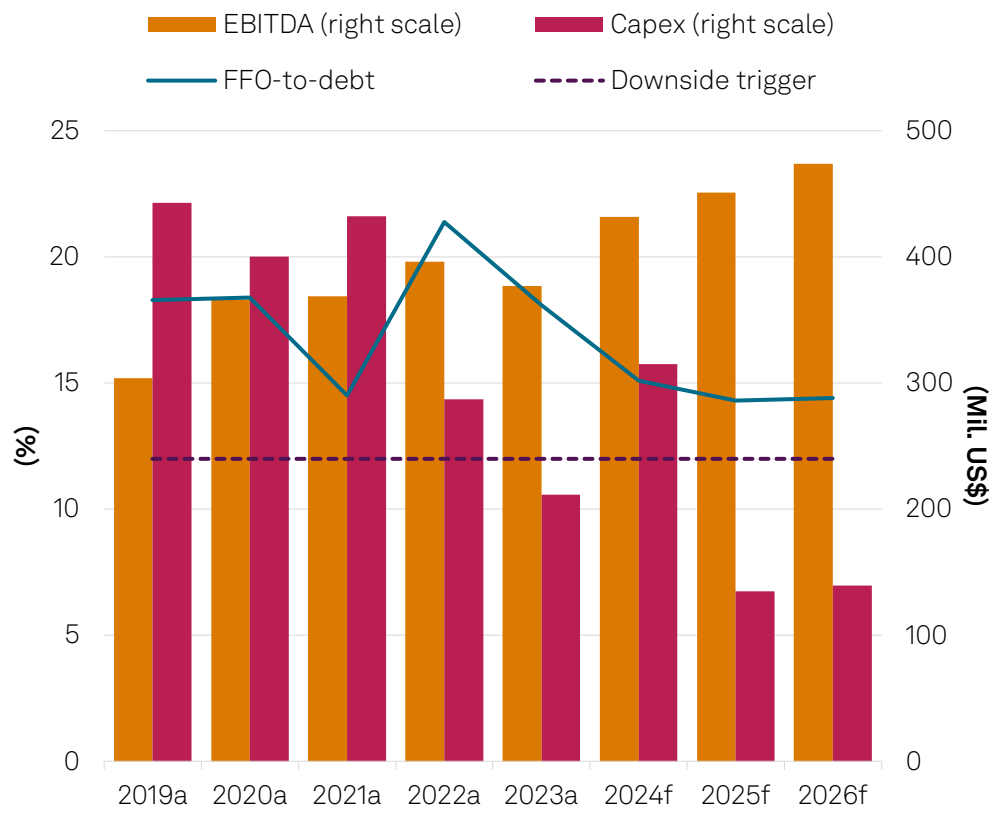
Issuer credit rating: **BBB/Stable/--** | Stand-alone credit profile: **bb**

Company description

- Integrated business model, including road cleaning, waste collection and transportation, and waste treatment.
- WtE capacity of 17,400 ton/day.
- Wholly owned by Beijing municipal government.

Rating snapshot

- Strong brand name with decades-long track record.
- Long-term service contracts and WtE concessions that bring visibility over revenue streams.
- Strong access to capital markets due to state-owned background.
- Delayed payment cycle from local governments weigh on cash flow.
- Increasing competition in sanitation contracts adds risks for contract bidding and pressures future EBITDA margins.



All figures adjusted by S&P Global Ratings. a--Actual. f--Forecast. Source: S&P Global Ratings.

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USA | Reworld Holding Corp.

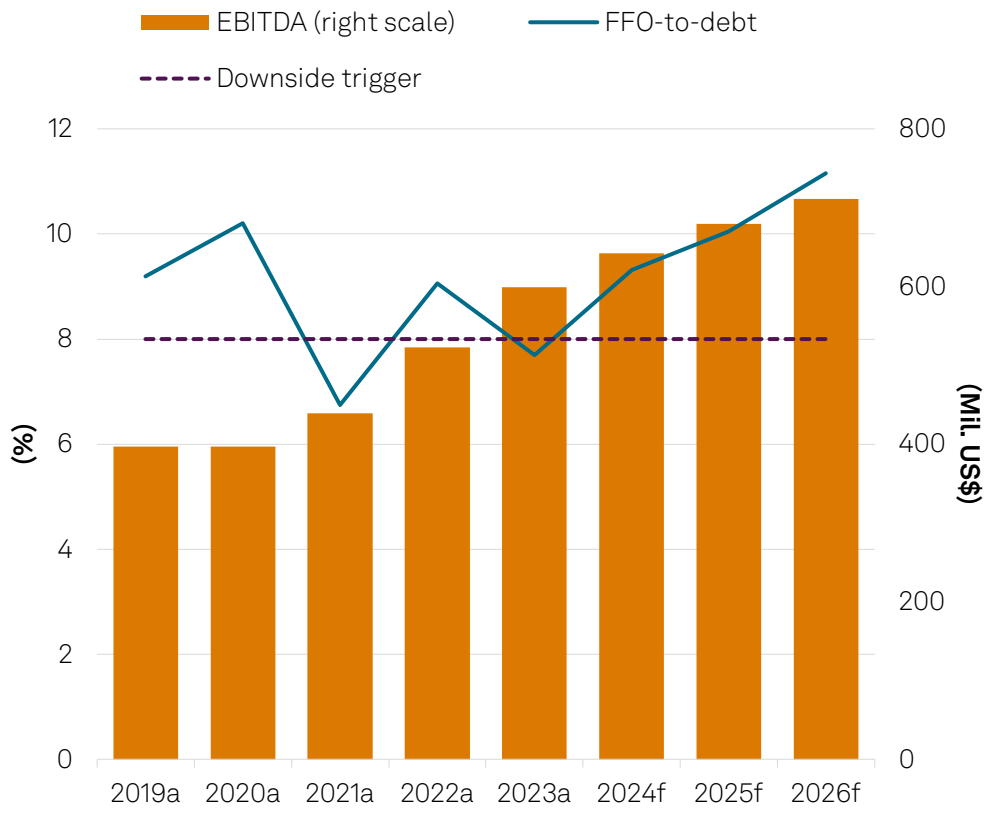
Issuer credit rating: **B+/Stable/--** | Stand-alone credit profile: **b+**

Company description

- Largest WtE operator in North America, with self-owned WtE capacity of 29,000 ton/day, and another 21,000 ton/day under O&M contracts.
- Also operates material processing facilities for liquids treatment, profiled waste, and waste solidification.

Rating snapshot

- Growing volumes and rising contract prices in profiled waste and at material processing facilities to raise earnings
- WtE volumes are 70%-75% contracted, with average of four years for owned plants and seven years for O&M contracts.
- Strong visibility on power sales revenue as over 85% of power generation through 2028 has locked in fixed pricing
- Elevated capex to improve boiler availability and earnings, limiting cash flow improvement.



All figures adjusted by S&P Global Ratings. a--Actual. f--Forecast. Source: S&P Global Ratings.

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Germany | EEW Energy From Waste GmbH

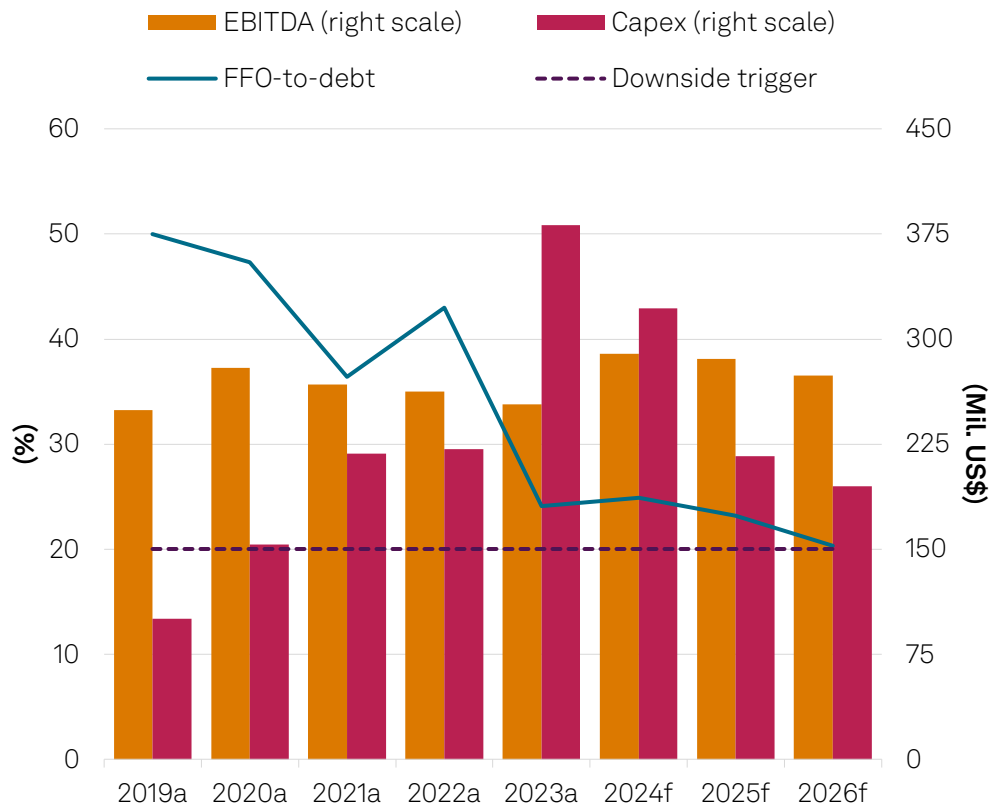
Issuer credit rating: **BBB-/Stable/--** | Stand-alone credit profile: **bbb-**

Company description

- Largest independent WtE company in Germany, with self-owned capacity of 11,000 ton/day and another 2,700 ton/day under operator contracts
- Wholly owned by Beijing Enterprise Holdings Limited, a state-owned company of Beijing government.

Rating snapshot

- Strong market position in a well-established and stable WtE market in Germany.
- High visibility and predictability of cash flow due to high share of medium- and long-term waste contracts.
- Update investment plan drives higher debt growth and higher leverage over 2024-2026



All figures adjusted by S&P Global Ratings. All figures refer to financial statements reported at EEW Holding GmbH, which diverge only marginally from EEW Energy from Waste GmbH's figures. a--Actual. f--Forecast. Source: S&P Global Ratings.

Europe | Other Rated Waste Players In Western Europe

An overview

	Country*	Company snapshot	Long-term ICR
A2A	Italy	Multi-utility company operating in the production, sale, and distribution of gas, electricity, and district heating, as well as urban and industrial waste collection and treatment and the integrated water cycle.	BBB/Stable/--
Hera	Italy	Multi-utility operating across four core segments: gas (distribution, retail sale, district heating), electricity (retail, distribution), waste (collection, treatment including WtE, recovery, disposal), integrated water cycle.	BBB+/Stable/--
Iren	Italy	Multi-utility active in the integrated water cycle, regulated networks (electricity and gas distribution), energy generation and retail, district heating, waste services including urban collection and disposal, as well as treatment.	BBB/Stable/--
Paprec Holding SA	France	Operates in the collection, sorting, waste-to-energy, and recycling of nonhazardous waste from private and public customers under multiyear agreements.	BB/Negative/--
Séché Environnement	France	Provides waste treatment services mostly for waste producers but also nonhazardous ones, servicing municipalities and industrial customers.	BB/Stable/--
Stockholm Exergi	Sweden	Largest district heating operator in Sweden, using about 30% of waste in their fuel mix. Also operates sizable waste handling system for the Stockholm area, where organic food waste, plastic and metal can be separated and be digested into biogas, reused or recycled.	BBB+/Negative
Tekniska verken	Sweden	Regional multi-utility company. For its district heating operations, waste has historically been its main fuel source, at near 60%, followed by recycled wood at about 35% on average. The company manages waste, also via import.	A+/Stable
Urbaser (Luna III)	Spain	Specializes in the collection, sorting, transfer, and treatment of urban waste. It also performs related activities, including urban cleaning, landscaping, industrial water management and cleaning, the sale of generated energy, and industrial waste treatment.	BB-/Stable/--
Veolia Environnement	France	Operates globally across water, waste and energy services. In the waste segment, it specializes in the collection, processing and disposal of municipal, commercial and hazardous and non-hazardous industrial waste.	BBB/Stable/--

*Main country of operations.

LATAM | First Rated Project Finance – Barueri Energia Renovavel

Issue credit rating: **brAA-/Stable/--**

Project description

- First WtE asset in Brazil under construction. Mooted for 1Q2027.
- Capacity to process 870 ton/day and generate 20 MW.
- First WtE financing rated under Project Finance globally

Rating snapshot

- About 60% revenues will come from fixed price regulated PPA due 2046, 17% from a 30-year waste treatment agreement, and remaining ancillary services, such as recycling and Carbon credit sales
- Certain exposure to market risk: 23% of revenues exposed to volume and price, including non-final waste treatment agreements.
- Construction and ramp-up risk are offset by guarantees provided by sponsors: Orizon Valorização de Resíduos (80%; brAA+/Stable) and SABESP - Companhia de Saneamento Básico do Estado de São Paulo (20%; BB/Estável/--, brAAA/Estável/--)

Operations Rating Snapshot	
Asset class operations stability (ACOS)	5
Operations phase business assessment (OPBA)	8
Min. debt service coverage ratio (DSCR)	1.17x (2027)
Downside resiliency assessment and impact	Modest (+1)
Median DSCR Impact	1.20x (Neutral)
Debt Structure impact	Neutral
Liquidity impact	Neutral
Refinancing impact	Not Applicable
Future Value modifier	Not applicable
Holistic analysis impact	Neutral
Structural protection impact	Neutral
Counterparty assessment impact	Neutral
Parent linkage and external influences	
Parent Linkage	Capped
Senior debt issue rating	**brAA-/Stable**

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