IRRC Waste-to-Energy Conference 2022

Global Supplier Structure for Delivery of EfW Plants, Including Alternative Processes, and Key Trends

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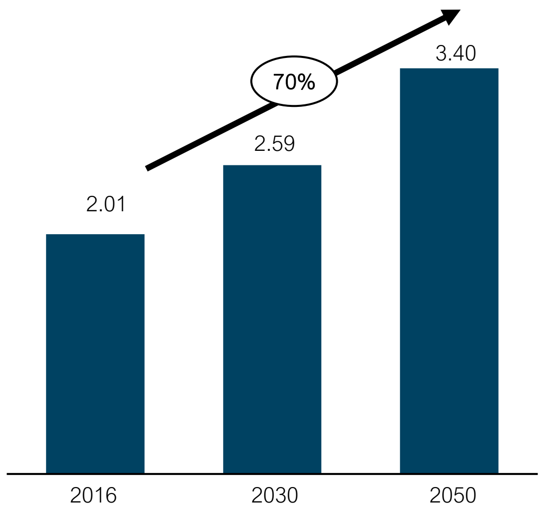
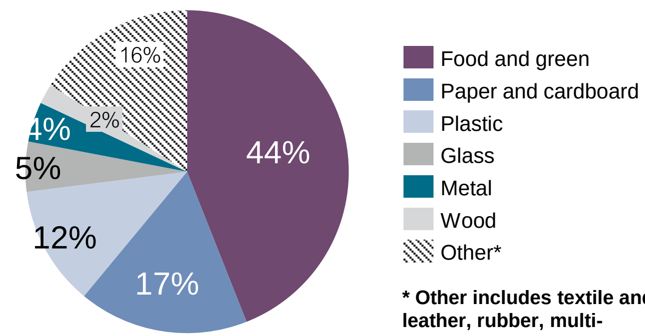
Municipal waste generation is expected to grow from 2bn in 2016 to 3.4bn in 2050, composed largely of organic matters

Global municipal waste generation and forecast (Billions of tonnes)



- Global municipal waste is growing at 2% CAGR and expected to reach 3.4 billion by 2050
- Growing global population and increased industrialization and urbanization in developing countries are the main drivers pushing the market growth

Municipal waste composition



*** Other includes textile and leather, rubber, multi-laminates, e-waste, appliances, ash, and other inert materials**

- Municipal waste generated by domestic and commercial sector is largely organic in nature, presenting 44% of total municipal waste
- Recyclable materials including paper and cardboard, plastic, wood, metal, and glass together accounting for 40%

Source: World Bank Report, UN world's population estimates

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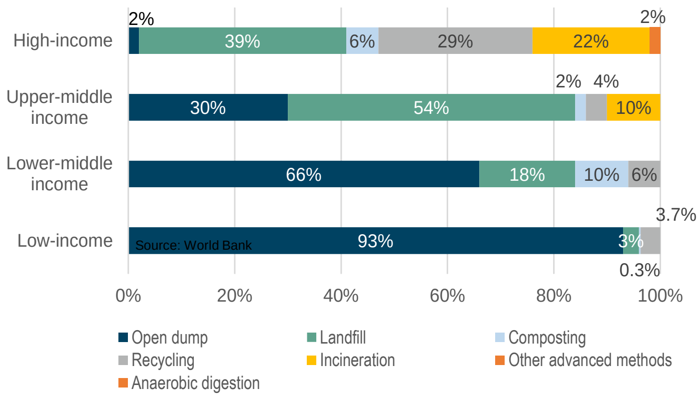
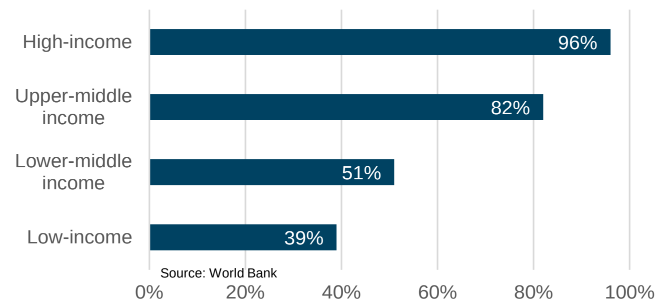
Duality of Waste Management Markets: High/Middle Income Markets versus Low(er) Income Markets

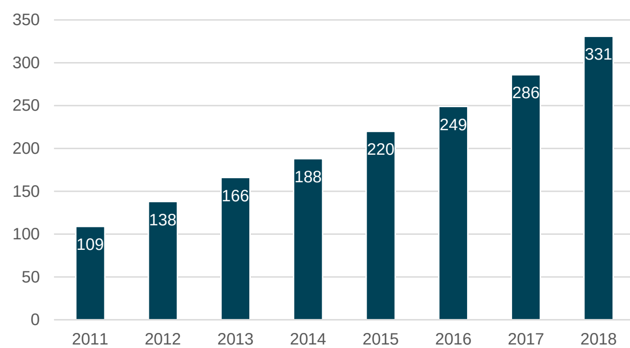
Disposal Methods by Income



Collection Rates by Income Level

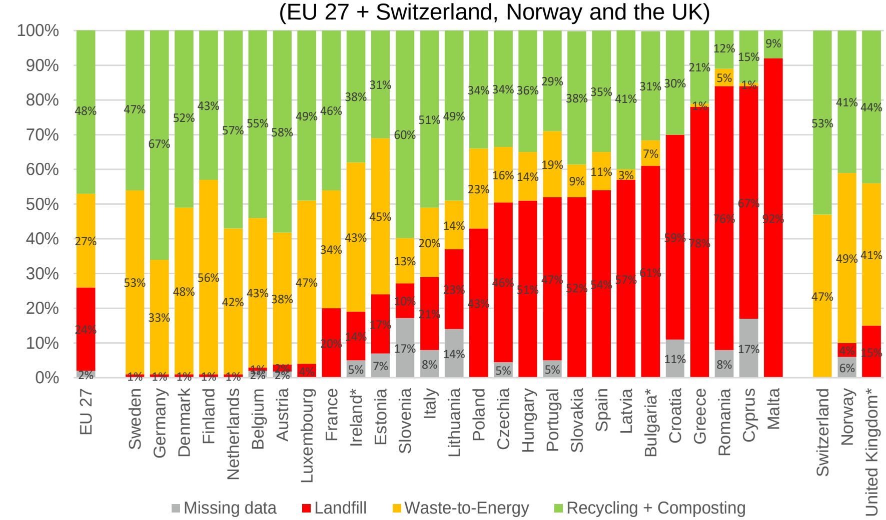


No. of waste incineration plants in China from 2011 - 2018



Municipal waste treatment in 2019

(EU 27 + Switzerland, Norway and the UK)



Source: World Bank, AVP Research

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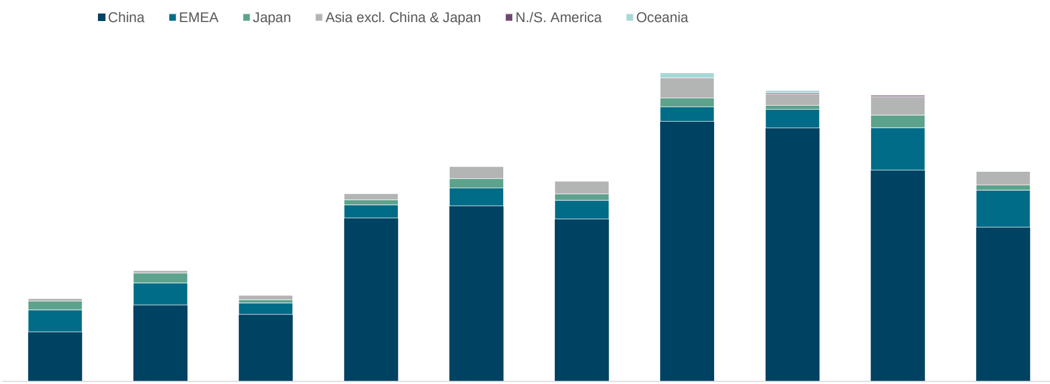
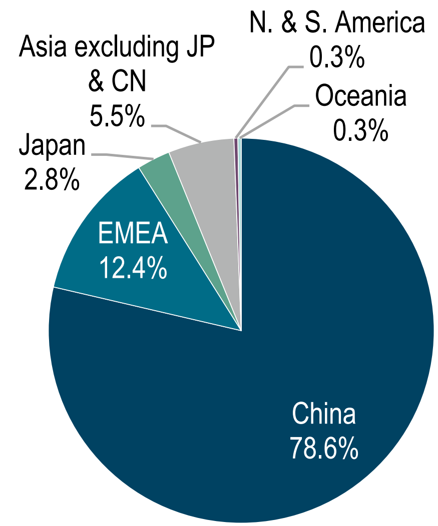
Global EfW Market Development 2012 – 2021: ~100 + plants/year, mostly in China
Total EPC market volume app Euro 10.9 billion average for the next 5 years

Global Awarded EfW Annual Capacity 2012 - 2021



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Capacity (tpd)	37'046	49'567	38'496	83'969	96'111	89'613	138'067	130'207	128'074	93'963	885'112
# of Awards	56	82	66	111	112	100	144	156	159	104	1'090

2017 - 2021



- EMEA awards in 2020 and 2021 are very high, over double compared to 10-year average. Driven by strong award volumes in UK, Middle East, and Germany, plus another 10 countries contributing.
- Japan is below 10-year average. Driven by upgrading, revamping and replacements, overall investment activity is expected to pick up again going forward
- After the 2019 peak year for Asia and Oceania (outside China and Japan) 2020 and 2021 shows a mixed picture, with significantly lower award volume, mainly driven by project delays and reduced awards in India.
- ***In 2019 and 2020 two large gasification projects (Fulcrum and Enerkem) were ordered***

Source: AVP Research

Overview EfW Supplier Structure

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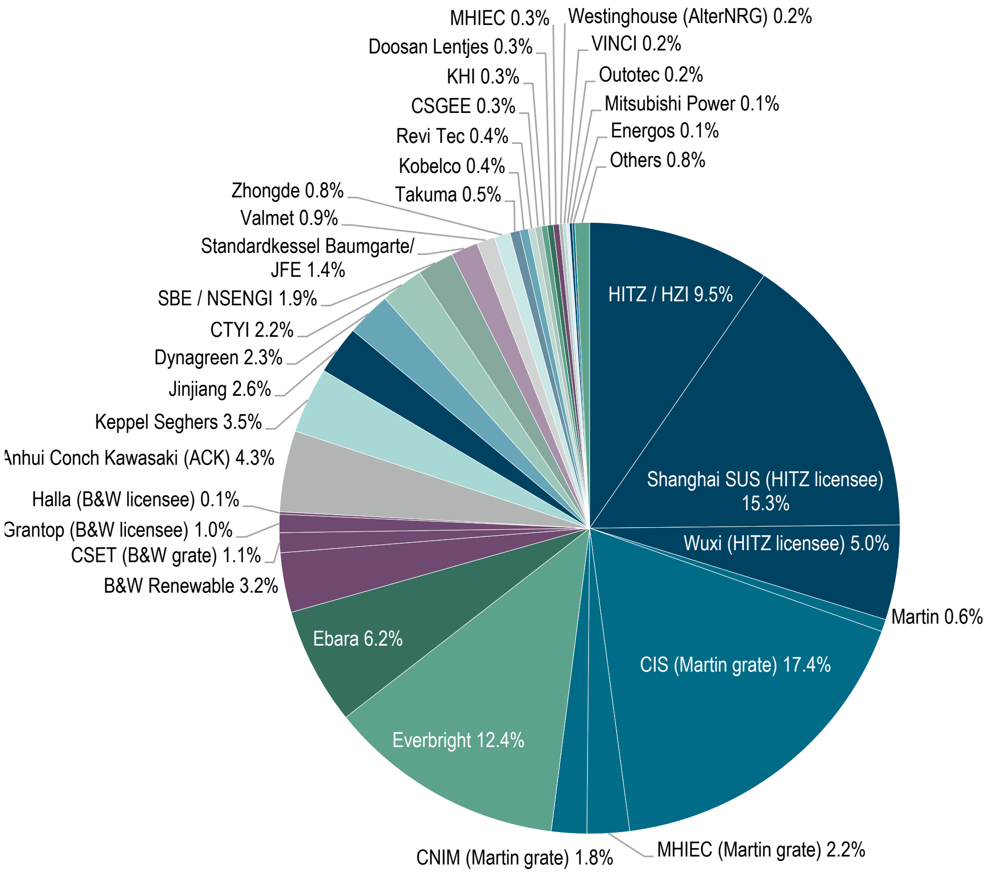
Past 10 years EfW technology awards to over 50 Companies recorded, however, over 50% of Global EfW Market using Grate Technology from HZI and Martin GmbH

Worldwide Shares by Suppliers 2012 – 2021



Total: 885'112 tpd

Industry structure and Way-to-Market

- Project/plant delivery quite fragmented with over 50 suppliers recorded
- Technologies used concentrated
  - Top two suppliers >45% market share
  - Top six suppliers > 75% market share
- Non-Chinese use similar "go to market strategies":
  a) Going direct in certain defined markets, in addition
  b) Working with strategic partners
- Only few technology suppliers offer turnkey (EPC)
- Often EfW incineration/gasification technology is sold to EPC companies, or the EPC contracts are offered in consortiums, whereas the EfW technology companies concentrate on boiler or Chute-to-stack tech packages

NOTE Martin owns three grate technologies: Martin reverse acting, SITY 2000 reverse acting, W+E horizontal

Hitachi Zosen also owns several grate technologies after take-over of Steinmüller Babcock Environment

Source: AVP Research

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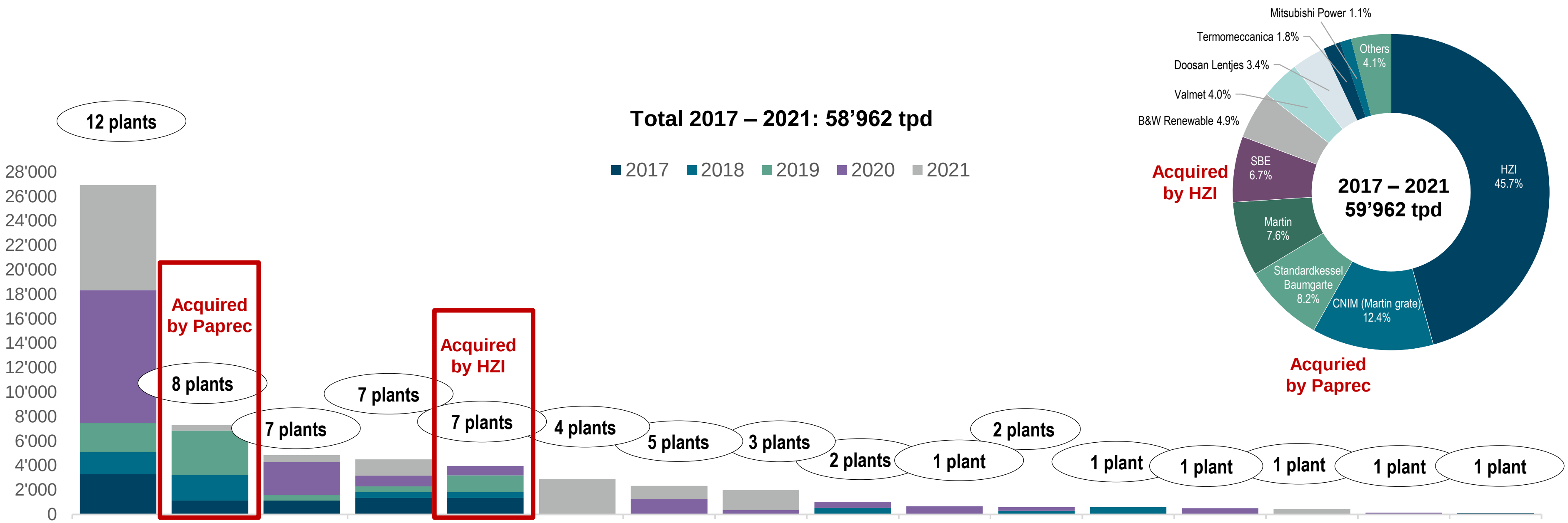
EMEA - The EfW Market is Concentrated with 4 to 5 Competitors Holding Over 75% Share, Further Consolidation in 2022 (red)



Competitors	HZI	CNIM (Martin grate)	SK/BBS	Martin	SBE	B&W Renewable	Valmet	Doosan Lentjes	Termo-meccanica	Mitsubishi Power	STC Power	Kobelco	Vital Energi	CTYI	Vyncke	Michaelis
EfW	Air/water-cooled grate	Reverse-acting grate (Martin cooperation)	Air/water-cooled grate (Koch license)	Grate: Reverse-acting (Martin, SITY 2000), horiz. (W+E)	Air/water-cooled grate DMS	Air/water-cooled grate (Dynagrate)	Fluidized bed (CFB/BFB)	Grate	No own technology (mostly ReviTec)	Grate (Koch origin)	Gasifier	FB gasific., melting furnace, grate, plasma melting furnace	Gasification	Air/water-cooled grate, plasma for fly ash	Grate	moved bed system fixed bed furnace rotary kiln
Turnover* (M€)	2'100 (240 Byen) Env. (FY 2019)	493*	156 (2019)	100.5 (2018)	279 (FY 2019)	109.3 (122M$)	3'740 (2020) 1'003 (Pulp & Energy)	n.a.	215.6*	90.4 B€ (12 trillion YEN (MP Group)	12'207* Cr	44'917 Myen* (waste treatment)	n.a.	M€ 91.8 (2018 WTE) (MRMB 178)	n.a.	n.a.
Employees #	700	2'500*	273 (2019)	191	300	450	14'046 (Total) 1'814 (Pulp & Energy)	176	673*	1'100 (Europe)	n.a.	2'871*	332	73'000	n.a.	n.a.
Owner	HITZ	Paprec	JFE Public	Private	HZI	Babcock & Wilcox, Public	Public	Doosan Group	Private, industrials	MHI	Sterling Wilson	Kobe Steel Public	Private	Publicly quoted	Private	Private

* CNIM: turnover for Env. Sector, employees for entire group; B&W: 2019; Termomeccanica: 2017 group figures; Kobelco: Group; STC Power: turnover parent company

Source: AVP Research

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Positioning of Major OEM in EMEA

BOO – Build Own Operate

DBO – Design Build Operate

EPC Wrap

OEM (Technology / Equipment Suppliers)

	Key WTE Processes / Technologies				Extended Services	
Companies	Grate / Boiler (thermal)	APC	Steam Thermal Cycle	IBA, Residue Treatment	Turnkey EPC	O&M
Hitachi Zosen INOVA	✓	✓	✓	–	✓	✓
MARTIN	✓	✓	–	(✓)	Partner	–
JFE Engineering Group Standardkessel Baumgarte	✓	–	✓	–	Partner	(?)
B&W Babcock & Wilcox Renewable	✓	✓	(✓)	–	Partner	–
DOOSAN Doosan Lentjes	✓	✓	✓	–	(✓)	–
Keppel Seghers	(✓)	(✓)	(✓)	–	–	(✓)
CNIM Innovate and Act / PAPREC	(✓)	–	(✓)	(✓)	(✓)	(✓)

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EfW is part of the Wider Resource Recovery Market

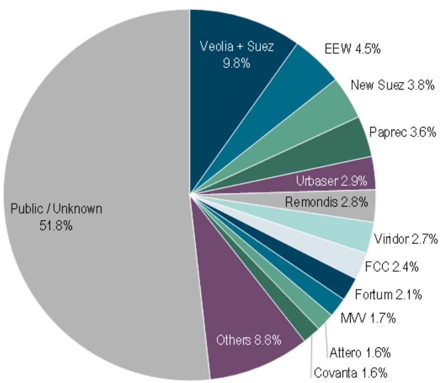
European waste market is actively being consolidated

Key strategic consolidators in Europe since 2021

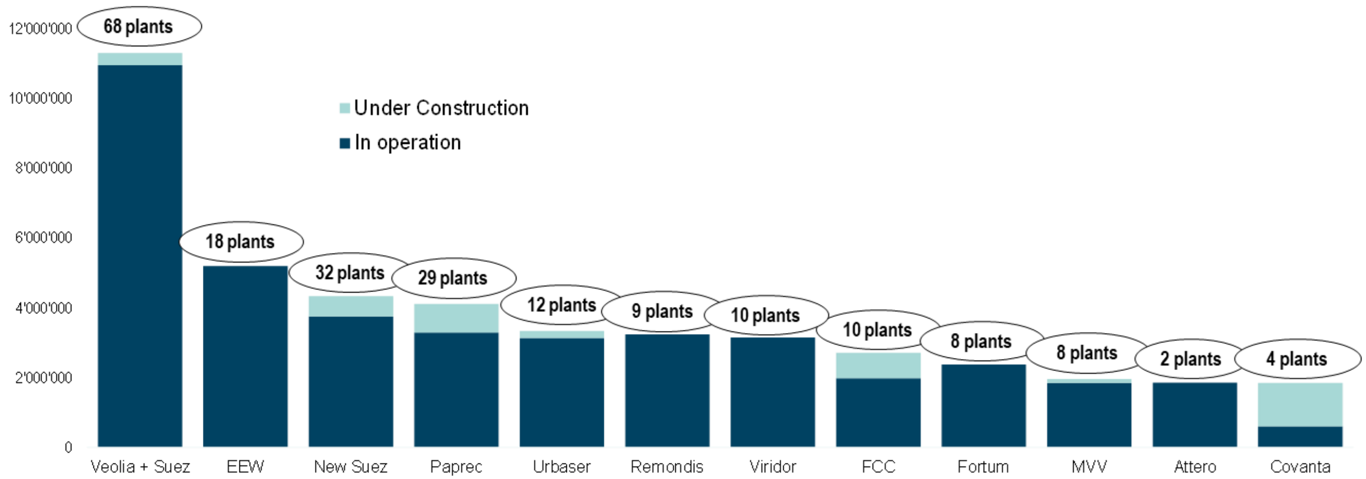
Company	No. Acquisitions (2021 – 22 YTD)	Type of business / strategy	Selected acquisitions
VEOLIA	5	▪ Pan-European M&A strategy ▪ Transformational merger with Suez	suez RVOSIS; suez; HUON
SCHWARZ pre zero	4	▪ Pan-European expansion strategy ▪ Transformational acquisitions from Suez	ferrovial Environmental Services business in Spain & Portugal; suez Europ. Waste Business Units; Virol
Biffa	4	▪ UK-focused & regional cluster driven M&A strategy ▪ I&C businesses	GREENCIRCLE RECYCLING; Viridor; COMPANY SHOP GROUP
Reconomy	4	▪ Increase presence internationally ▪ Strategic focus on reverse logistics and technology	casepak; advanced; EUROKEY; ReBOUND
REMONDIS	4	▪ Strengthening geographical presence across Europe with focus on the German home market	VEOLIA Recycling Solutions Nordic AB; Fehr 13 Locations; K+S Waste Management Busines
PAPREC RECYCLAGE	4	▪ Primarily focused on consolidation of waste management market in France, however, several recent deals in LATAM	Actiplast; PIZZORNO ENVIRONNEMENT; dalkia wastenergy; CNIM Operations & Maintenance
urbaser	2	▪ UK and Nordics focused strategy ▪ Collections and treatment businesses	J&B RECYCLING; amey

Source: AVP Research

The European private EfW owner/operator market is around € 4 – 6 Billion and growing at approx. 6% per year



Total O&M Market: 115.1.3 mtpa



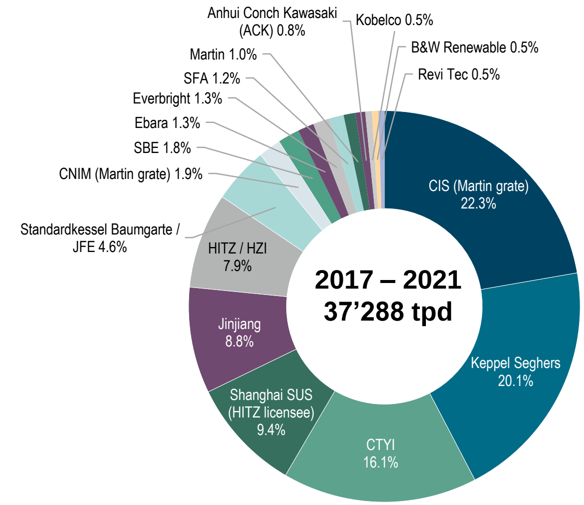
Total Private O&M Market: 55.5 mtpa

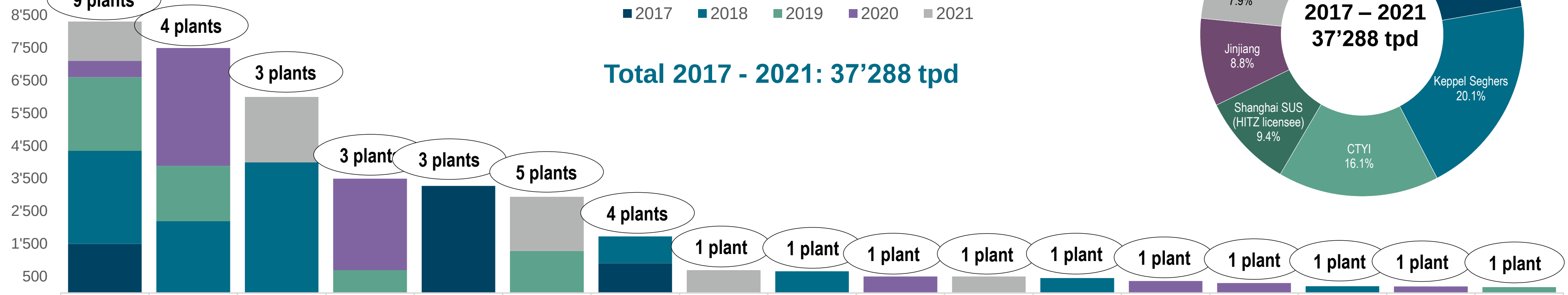
Key Messages

- The split between private and public operators of installed base in Europe is is app 50/50%
- In the past 10 years the share of private operation has grown significantly in newly developed projects
- The private EfW operator market is app. 53.2 mtpa and still fragmented with currently over 30 identified private operators
- EEW is the largest pure play EfW company in Europe (business model fully focused EfW)
- Key success factors for BOO development and private operation: Bankability of developer, EPC and operator, track record, financial strength, best-in-class operational capabilities

Source: AVP Research

Asia* - Overview OEM/Technology Suppliers, CIS (Martin Lic.) and Keppel highest Market Share





Competitors	CIS* (Martin grate)	Keppel Seghers*	CTYI	Shanghai SUS (HITZ licensee)	Jinjiang*	HZI / HITZ	Standardkessel Baumgarte/ JFE	CNIM (Martin grate)	SBE	Ebara Environmental Plant Co., Ltd.	Everbright*	SFA Handels GmbH	Martin	Anhui Conch Kawasaki	Kobelco	B&W Renewable (Volund)	Revi Tec
EfW	SITY 2000 from Martin (reverse acting)	Air/water-cooled grate	Air/water-cooled grate, plasma for fly ash	Grate (HITZ)	CFB, Grate	Air/water-cooled grate	Air/water-cooled grate (Koch license)	Reverse-acting grate (Martin cooperation)	Air/water-cooled grate DMS	Air/water-cooled grate / FB / FB gasification / Internally Circulating FB	CEIL Grate, CFB, Gasif.	Air-cooled / WC Grate	Grate: Reverse-acting (Martin, SITY 2000), horiz. (W+E)	Grate	FB gasification, melting furnace, grate, plasma melting furnace	Air/water-cooled grate (Dynagrate)	Grate
Turnover* (M€)	4.32 BCNY	M€ 25.69	M€ 91.8 (2018 WTE) (MRMB 178)	n.a.	2’209.2 RMB million (WTE) Total: 3.878 BRMB	2’100 (240 Byen) Env. (FY 2019)	156 (2019)	493*	279 (FY 2019)	MYen 523’727 (2020) – Ebara consolidated	BHK$ 15.72 Total: BHK$ 37.56	Unknown	100.5 (2018)	Unknown	51’711 MYen* (waste treatment)	109.3 (122M$)	Unknown
Employees #	2’395	91	73’000	n.a.	2’756	Total HITZ: 10’707 HZI: 700	273 (2019)	2’500*	300	2’027 (2018)	≅13’200	Unknown	191	Unknown	2’916*	450	Unknown
Owner	Publicly quoted / Sanfeng Env. Group	Keppel Infrastructure	Publicly quoted	Majority share CITIC PE	State-owned	Hitachi Zosen Corp. Public	JFE Public	Paprec	Nippon Steel (NSENGI)	Ebara Corporation	Public / State Owned	Private	Private	Kawasaki Plant , Anhui Conch	Kobe Steel Public	Babcock & Wilcox, Public	Private

* Kobelco: Group, in January 2019, waste treatment business of IHI Enviro Corp consolidated into group; Andritz AE&E: Pulp & Paper Division figures; HZI/HITZ: Env. Systems & Ind. Plants Div., Keppel Seghers: DnB Info, Keppel Infrastructure Division, MHIEC: Industry & Infrastructure Business Segment, KHI: Energy System & Plant Eng’g Division, CIS: Chongqing Sanfeng Environment (online WSJ markets 2019), Jinjiang: FY 2019. Everbright: Environmental Energy Division

Source: AVP Research

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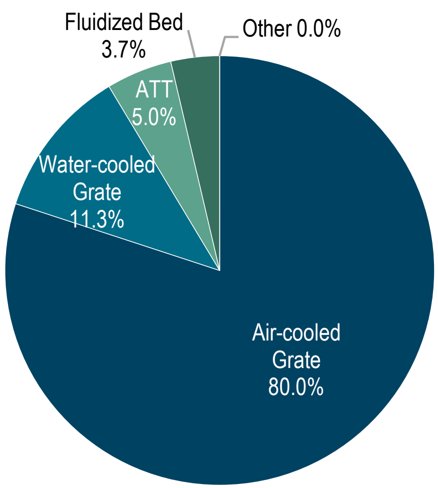
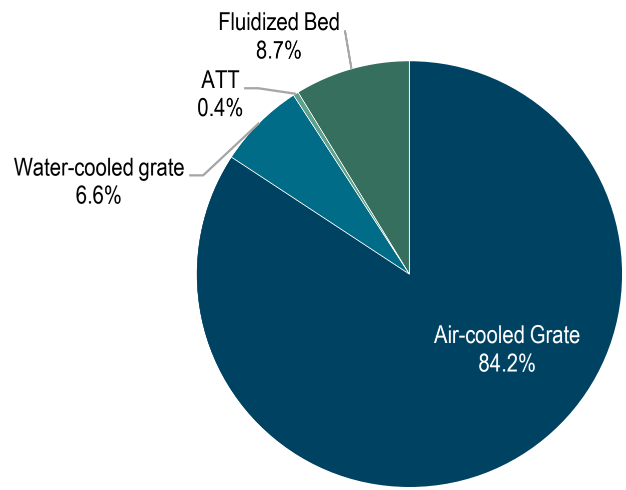
EMEA and Asia* - Grate Incineration is Dominant with c. 90% Market Share Gasification/Pyrolysis (ATT) Fluctuates Around 4-6%

EMEA Market Segmentation by Technology 2012 - 2021



Total: 97’468 tpd

Asia* Market Segmentation by Technology 2012 - 2021



Total: 49’459 tpd

Key Messages

- Grate Incineration Technology is used for c. 90% of the EfW Projects
- ATT fluctuate around 4-6% market share
- Japan has traditionally higher ATT market share (currently app 20%, driven by requirement for high quality bottom ash)
- Fluidized bed is mainly promoted by Valmet and Jinjiang in Asia
- Water cooled grates are mostly used in Europe for (pre-) RdF and SRF (higher CV)

Source: AVP Research ** ATT (Alternative Thermal Technologies)*

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Alternative Technologies are Mostly Aimed at (Jet-) Fuel Production, with Chemical Recycling of Plastic Waste Emerging

Company	Projects in Operation, Commissioning and Planning
Enerkem, Suncor	**Enerkem Alberta Biofuels**: **waste-to-biofuel** (biomethanol, cellulosic ethanol), in commissioning
Enerkem, Suncor, Shell, Proman	**Enerkem Varennes, Québec**: **biofuels and renewable chemicals** plant with strategic partners Shell, Suncor, Proman & Hydro-Québec, under construction, Phase 1 commissioning scheduled 2023
Enerkem, Shell, Port of Rotterdam	**Enerkem Rotterdam**: consortium partners Shell, Port of Rotterdam for **waste-to-jet fuel (Sustainable Aviation Fuel – SAF)**, (360K tpy) in development, pending Final Investment Decision
Enerkem, Agbar, Veolia, Repsol, ecoplanta	**Enerkem Ecoplanta, Tarragona, Spain**: JV Repsol, Enerkem, Agbar for **waste-to-circular methanol**. One of 7 preselected by European Commission **Innovation Fund**. Expected commissioning 2026.
Fulcrum BioEnergy	**Sierra BioFuels Plant, Reno, NV**: **waste-to-transportation fuels** from 175 ktpy landfill waste, start-up May 2022
	Centerpoint BioFuels Plant, Gary, IN: **waste-to-SAF** from 700 ktpy waste, estimated completion 2025
	Trinity Fuels Plant, US Gulf Coast: **waste-to-SAF** from 700 ktpy waste, estimated completion 2025
Fulcrum BioEnergy, Essar	**Fulcrum NorthPoint, Cheshire, UK**: Essar Stanlow Manufacturing Complex, **waste-to-SAF** from 600 ktpy waste, awarded grant from UK Govt. Dept. for Transport, estimated completion 2027
Velocys, Japan Airlines, Toyo Engineering	**Demonstration plant, Nagoya, Japan**: SAF from woody biomass residue feedstock used in **commercial flight by JAL** (JAL #515) from **Tokyo to Sapporo** on **June 17, 2021**. Plans for commercial-scale production of SAF in Japan.
Velocys, Department for Transport, British Airways	**Altalto, Immingham, UK**: **waste-to-SAF** from 500 tpy household & office waste in collaboration with British Airways, target financial close 2024, estimated completion 2027
Velocys, Oxy	**Bayou Fuels, Natchez, Mississippi**: **woody waste to SAF** (process waste from paper & lumber industries). In partnership with **Oxy Low Carbon Ventures, will use CCS** (carbon capture and storage). CO2 produced in process will be captured and sequestered underground
Kobelco, CoGen	**Hooton Bio Power Facility, Wirral, North West England**: first non-subsidized merchant gasification facility. Start-up slightly delayed, expected 2022

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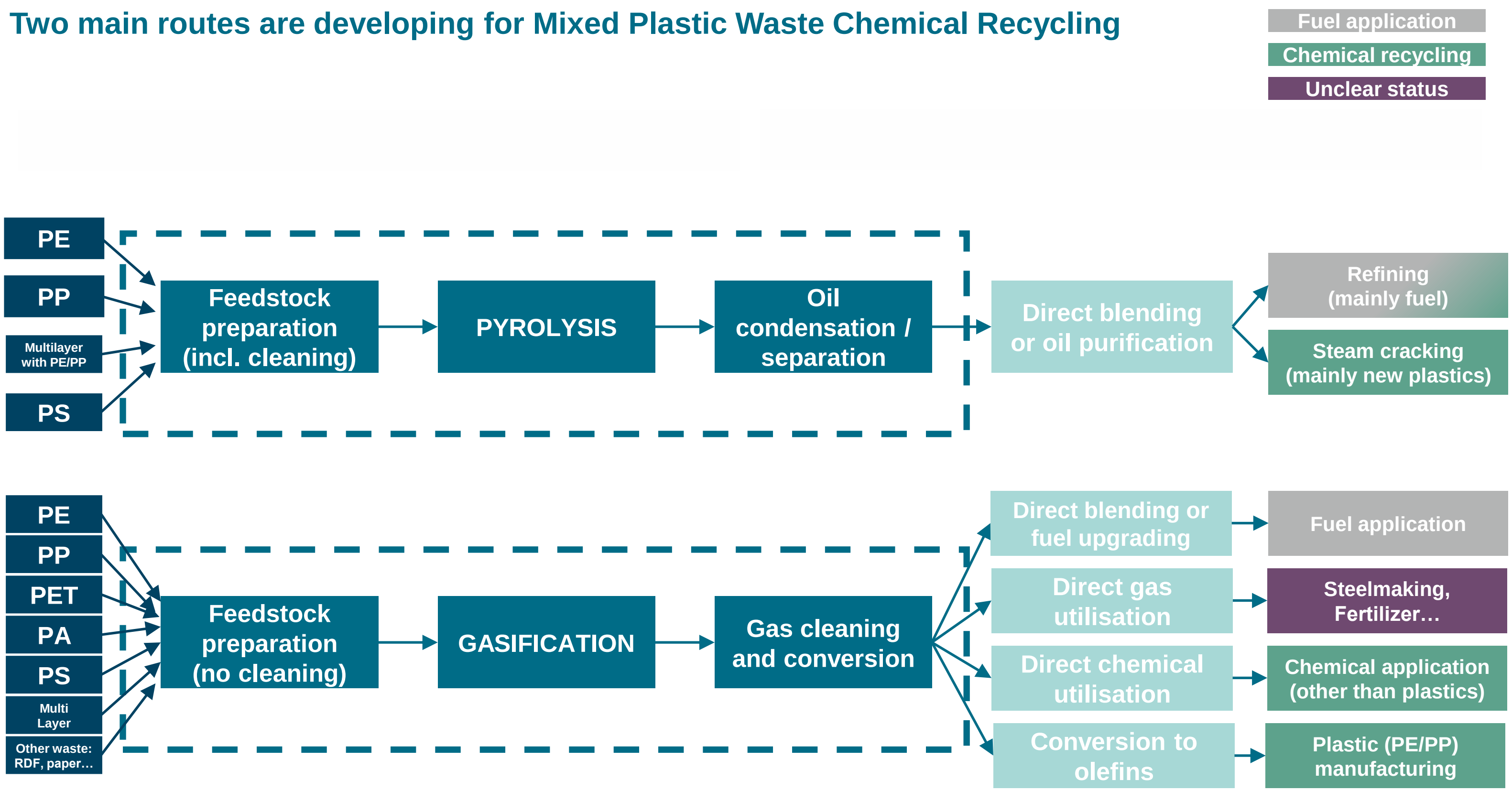
Gasification/Pyrolysis (ATT) in Chemical Recycling of Plastic (1/2)

Two main routes are developing for Mixed Plastic Waste Chemical Recycling



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Gasification/Pyrolysis (ATT) in Chemical Recycling of Plastic (2/2)

Both routes are being industrialized with commercial projects in development or in realization:

PYROLYSIS

TRL scale

4	5	6	7	8	9
Lab-scale	Pilot - Prototype	Pilot - Validation	Demo	First commercial	Fully proven

- PLASTIC ENERGY (World leader in chemical recycling): *2 plants operated H24 in Spain, 5 plants in project*
- QUANTAFUEL: *First commercial plant in commissioning*
- Recycling Technologies: *First industrial plant in construction in Scotland*
- BRIGHTMARK: *First industrial plant (100 kt/yr) in construction in the US*
- fuenix: *Money raised in July 2020 (4 M€) for scale-up*
- OMV: *Pilot plant in operation since 2018*

GASIFICATION

TRL scale

4	5	6	7	8	9
Lab-scale	Pilot - Prototype	Pilot - Validation	Demo	First commercial	Fully proven

- EBARA: *Industrial plant in operation since 2003, use of gas in fertilizer plant*
- Enerkem: *Demo plant in Edmonton (ethanol), 2nd commercial project in construction*
- Fulcrum BioEnergy: *First industrial plant in construction in the US (fuel application)*
- NextChem: *Several industrial plants in operation in Japan but with gas combustion (no chemical recycling). Projects in development in Italy with ENI*
- VELOCYS: *Technology packages are selected, 2 projects in development for waste-to-fuel. The financial close of UK project expected for 2021*
- ENGIE: *Pilot plant in operation for wood feedstock, trials planned in 2020 with SRF*

Outlook for Structural Development of the EfW Industry

2010 → 2015: **Globalization of Suppliers**	2015 → 2020: **«Industry Shake out»**	2020 → 2025: **«New Ecosystem»**
Global footprint needed to achieve critical size Asian owners move into European EfW market: ▪ M+A: Keppel, HITZ, others ▪ OEM and Asset acquisitions ▪ UK market becomes most important in EMEA ▪ Chinese suppliers mostly focused on domestic opportunities	Dominance of UK EPC market triggers shake out ▪ Move to UK, into EPC (risk) ▪ Break into new markets: Aus, ME, RU, India ▪ Hugh industry losses BOO asset value peak triggers M&A First Chinese suppliers internationalizing	➢ ***Energy transition and decarb context*** ➢ ***European market tailing out*** ➢ ***Strong global market need in new markets*** ➢ ***Waste-to-X (not power)*** ➢ ***Separate need for plastic processing*** ➢ ***Need for bankable EPC solutions and O&M*** ➢ ***Chinese internationalizing*** ***New bus models, trigger fight for*** ➢ ***O&M and asset control*** ➢ ***Sector coupling*** ➢ ***Data based digital services***
▪ Intensified sales activities ▪ Global value chain ▪ Create global synergies	▪ EPC capabilities and risk mgt ▪ Develop and enter new markets ▪ Win or loose	➢ ***Need for end-to-end solution for RSW (residual solid waste)*** ➢ ***Business model transition*** ➢ ***Broader value generation, deep expertise*** ➢ ***“Winners take it all”***

Source: AVP Research

Thank you for your attention! Questions – Comments?

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