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Zero Waste with Energy from Waste

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Zero Waste – Is it Possible?

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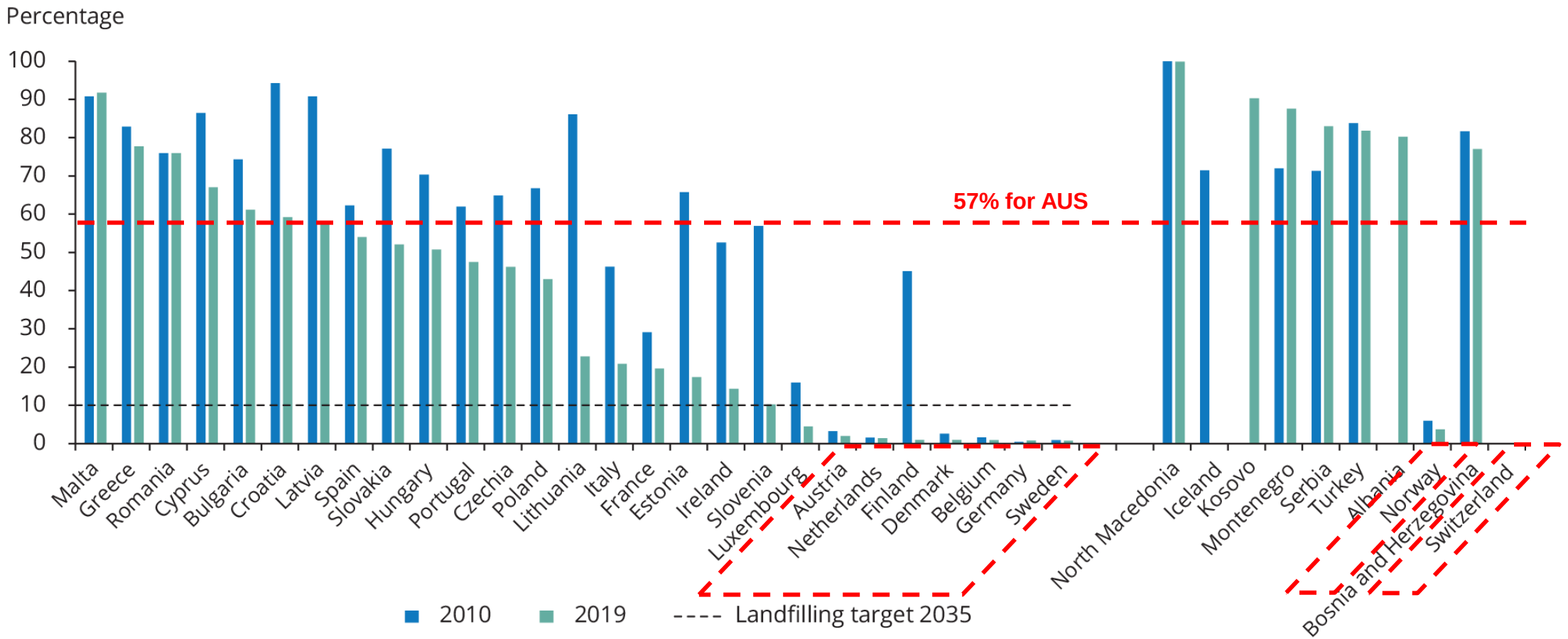
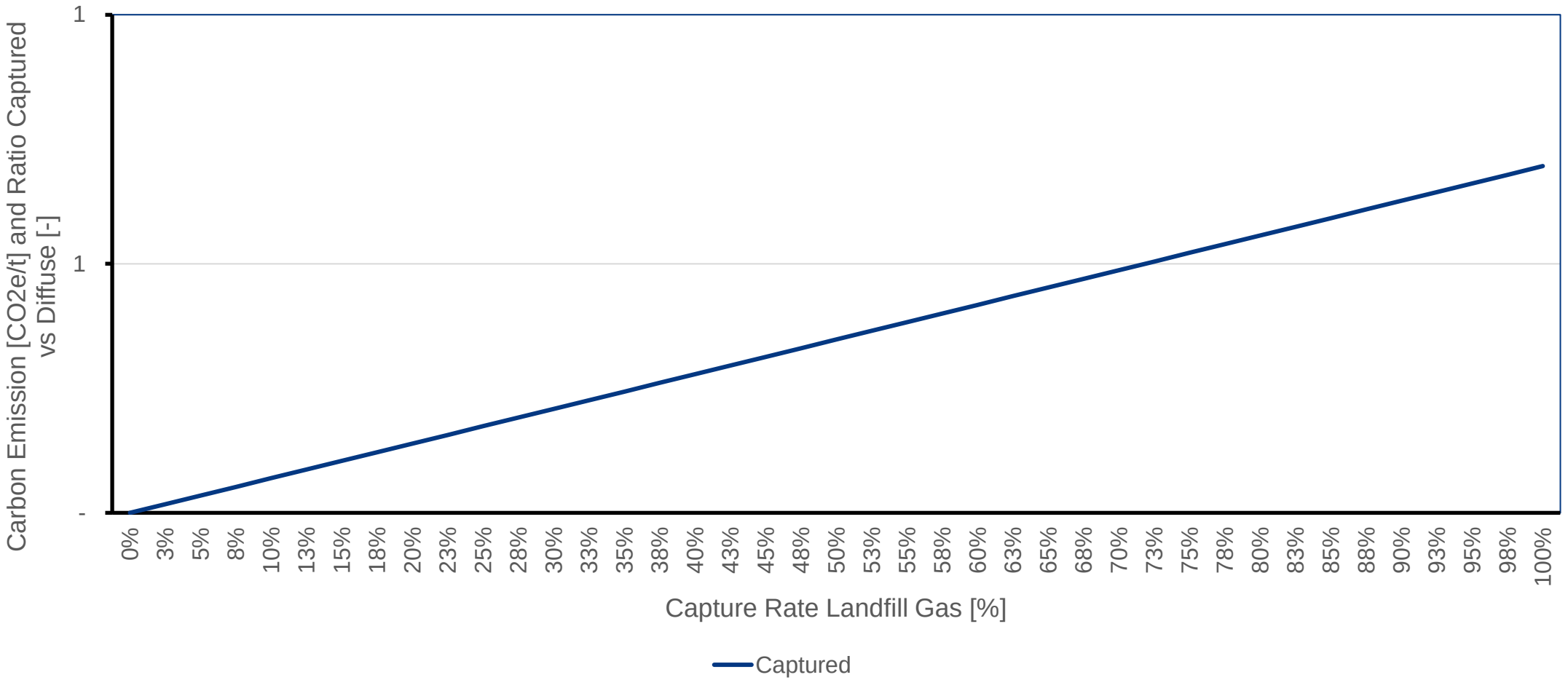
Best in Class municipal waste landfill rates in Europe (EC and non-EC)

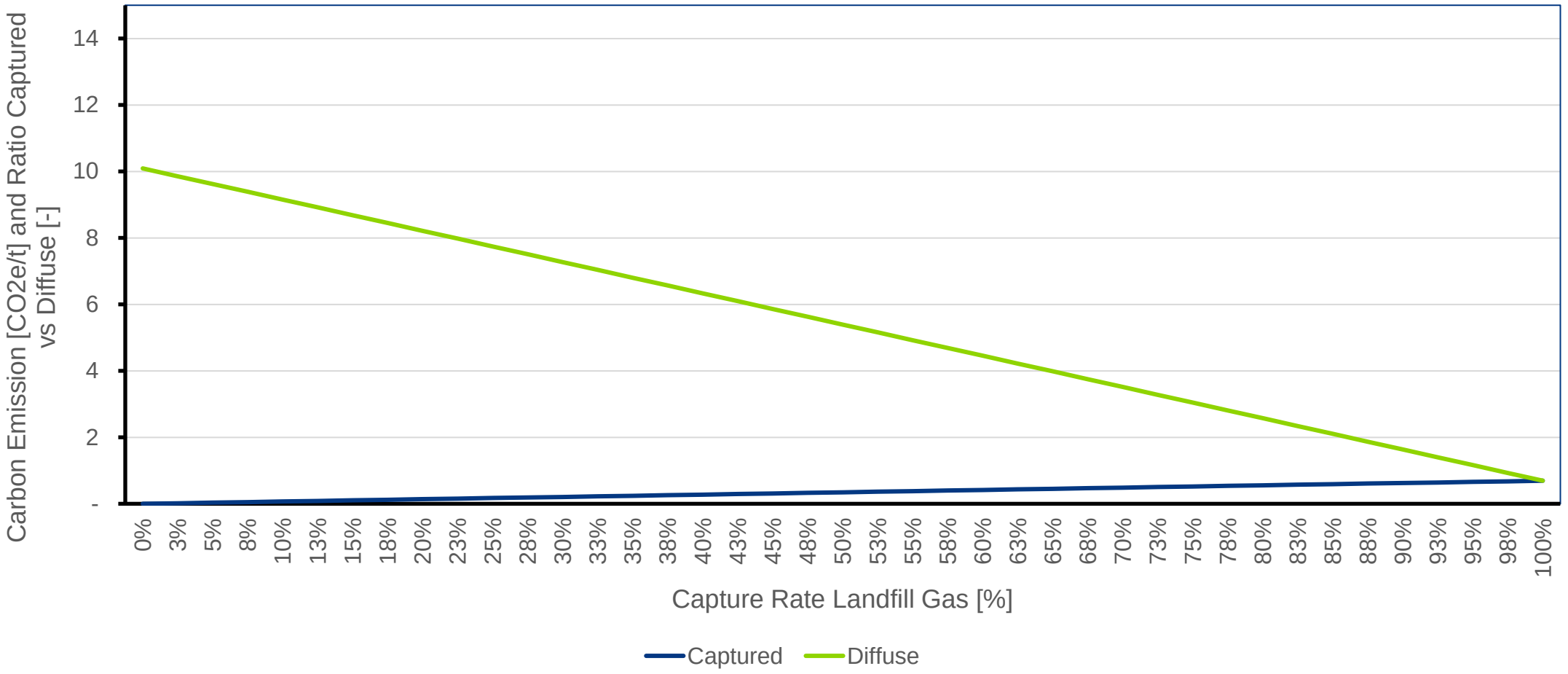


Reference: European Environment Agency
https://www.eea.europa.eu/ims/diversion-of-waste-from-landfill **(downloaded 19 Oct 2022)**

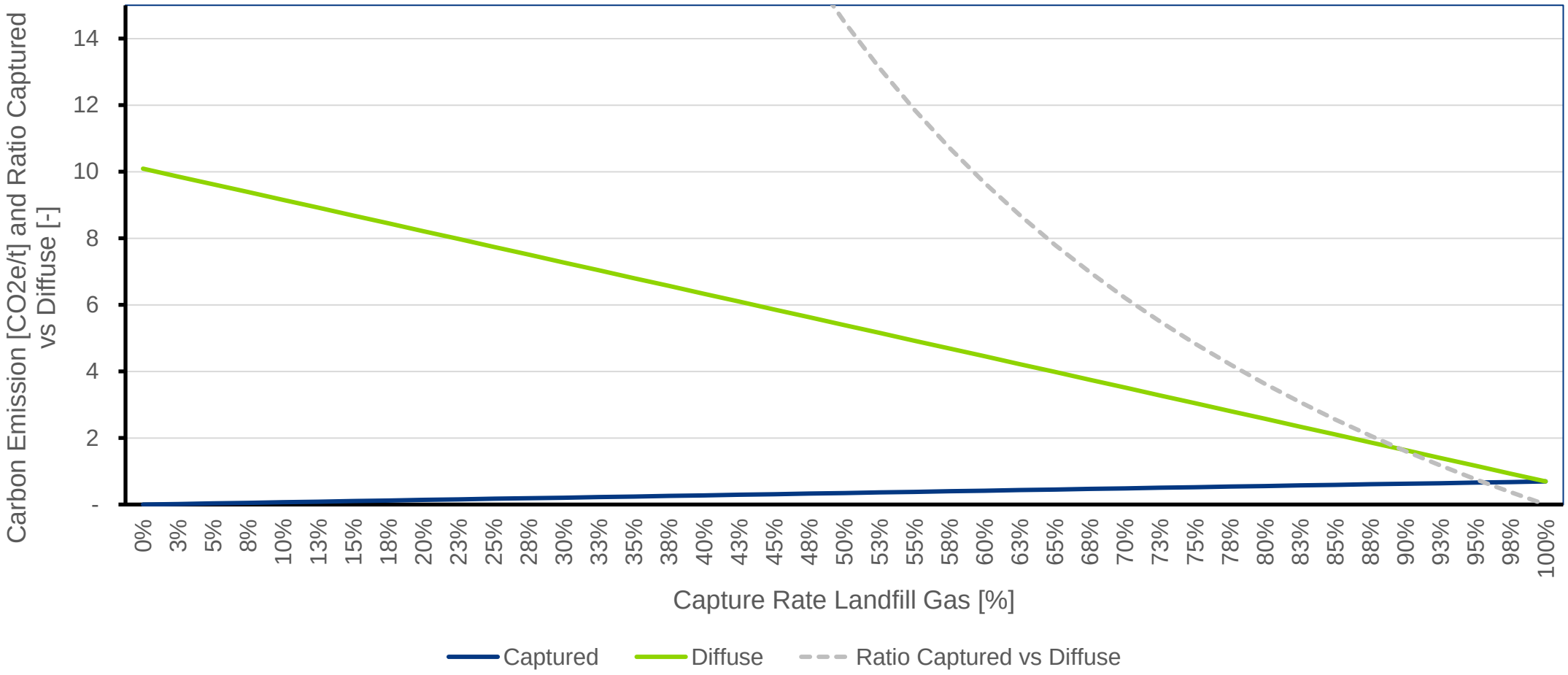
Capturing of landfill gas is good!



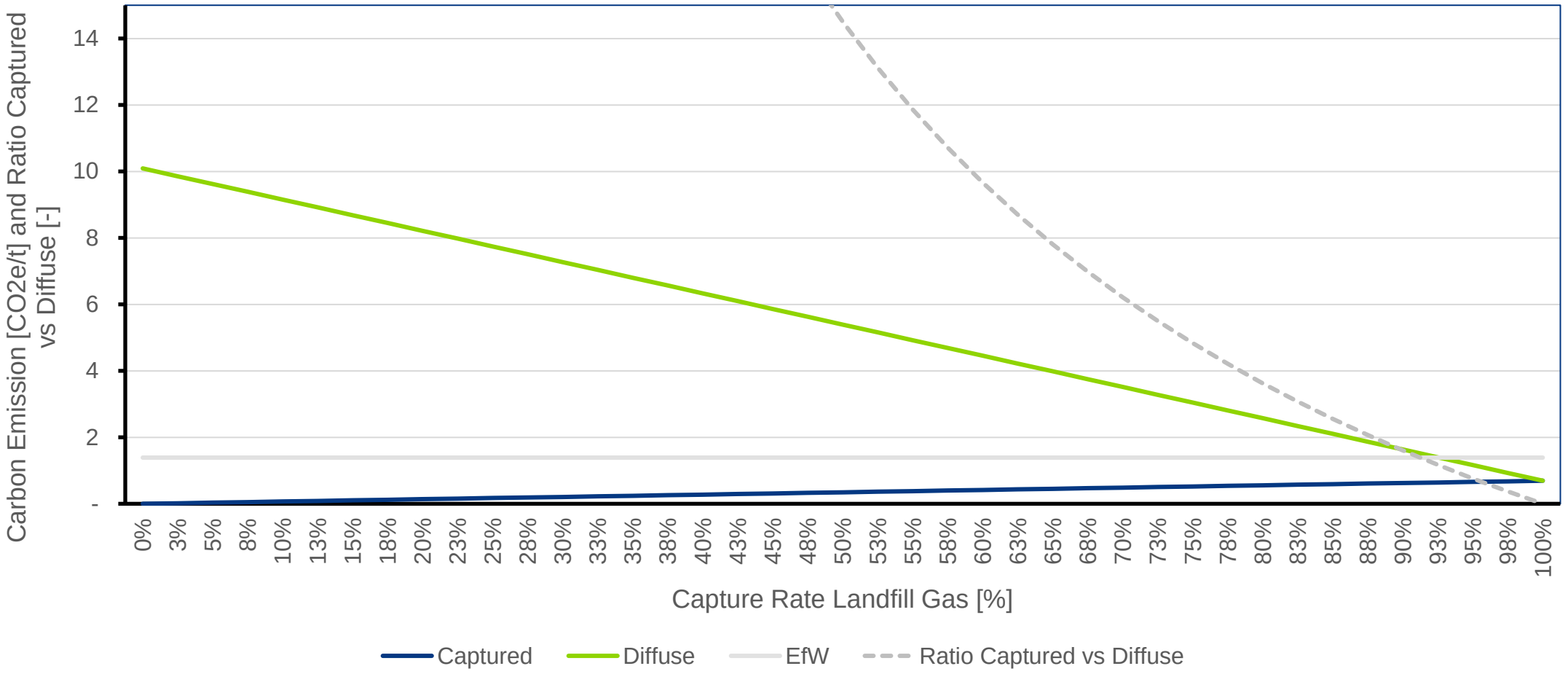
The diffuse landfill gas is 50% to 60& methane leading to high CO_2e



Landfills need a gas capture rate of around 97% to become carbon neutral



EfW has a better carbon foot print than landfills up to around 93% gas capture rate



EfW will beat landfills at all times
Residual waste to landfills pollutes for more than 100 years

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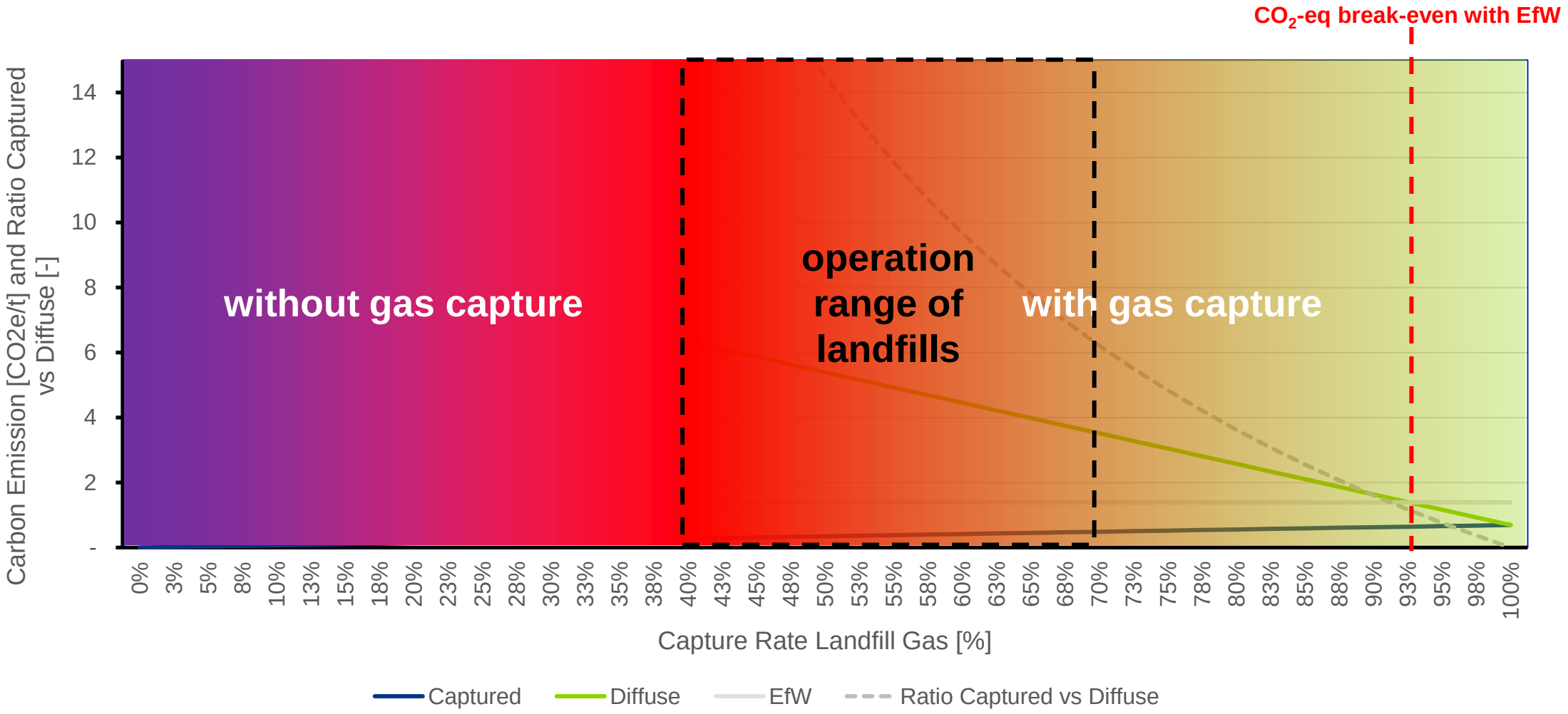
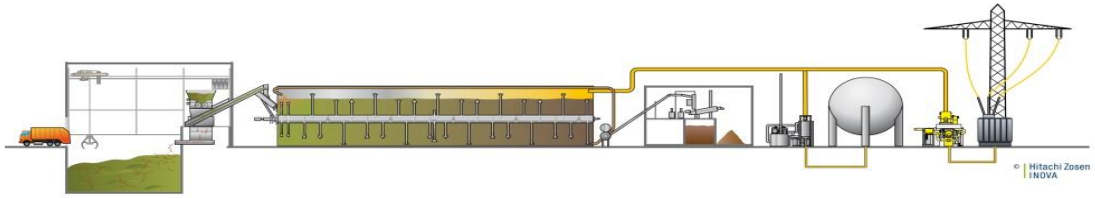
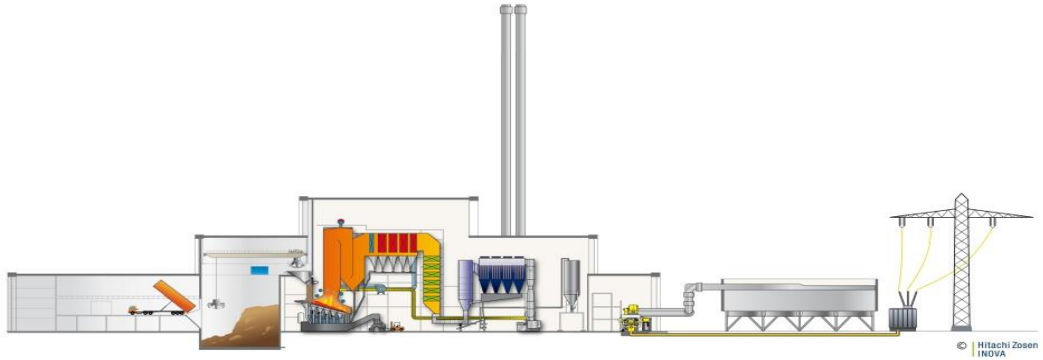


We need at least three bins to achieve “zero waste to landfill”

Energy & Compost
from biowaste with
anaerobic digestion

Energy & Material
from non recyclable waste with
thermal treatment





Recycling
- Compost & fertiliser

Direct Recycling
- Glass, paper, metals

Recycling
- Metals & minerals

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Zero Waste from EfW – Is it Possible?

Energy from Waste and the solid residues outputs

- none-recyclable waste
- additives for flue gas cleaning

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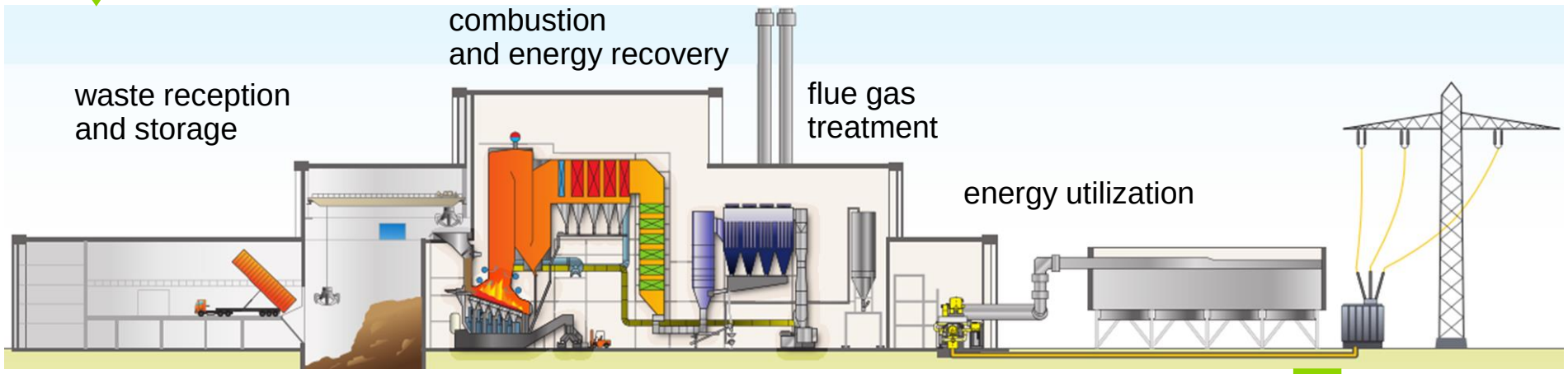

- energy - electricity and heat
- bottom ash with metals
- cleaned flue gas
- flue gas treatment residues

OUT

Minimise the waste from EfW

Regulatory and social drivers:

- “End of Waste” regulations
- Regulatory pathways for re-use
- Willingness to further detoxify
- Willingness to pay for the circular economy

Landfill cost:

Landfill OPEX	Landfill Levy	Landfill Gate-Fee
$50/t	$0/t	$50/t
$50/t	$50/t	$100/t
$50/t	$100/t	$150/t
$50/t	$150/t	$200/t
$50/t	$200/t	$250/t

Impact of Landfill Levies on Residues (based on dry FGTR System)

Landfill OPEX	Landfill Levy	Landfill Gate-Fee
$50/t	$0/t	$50/t
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Impact of Landfill Levies on Residues (based on dry FGTR System)

Landfill OPEX	Landfill Levy	Landfill Gate-Fee	Impact on EfW Gate-Fee for Disposal of Bottom Ash (25%)	Impact on EfW Gate-Fee for Disposal of FGTR (2 x 4%)	Impact on EfW Gate-Fee for Disposal of all Residues
$50/t	$0/t	$50/t	$12.5/t	$4/t	$16.6/t
$50/t	$50/t	$100/t	$25.0/t	$8/t	$33.0/t
$50/t	$100/t	$150/t	$37.5/t	$12/t	$49.5/t
$50/t	$150/t	$200/t	$50.0/t	$16/t	$66.0/t
$50/t	$200/t	$250/t	$66.5/t	$20/t	$86.5/t

- **Residue cost drive EfW Gate-Fee**
- **Most other countries have zero levy on residues to landfill as waste management is regulatory driven**
- **Recycling of the solid residues maximises circularity, and minimises the carbon-footprint and the gate-fee**

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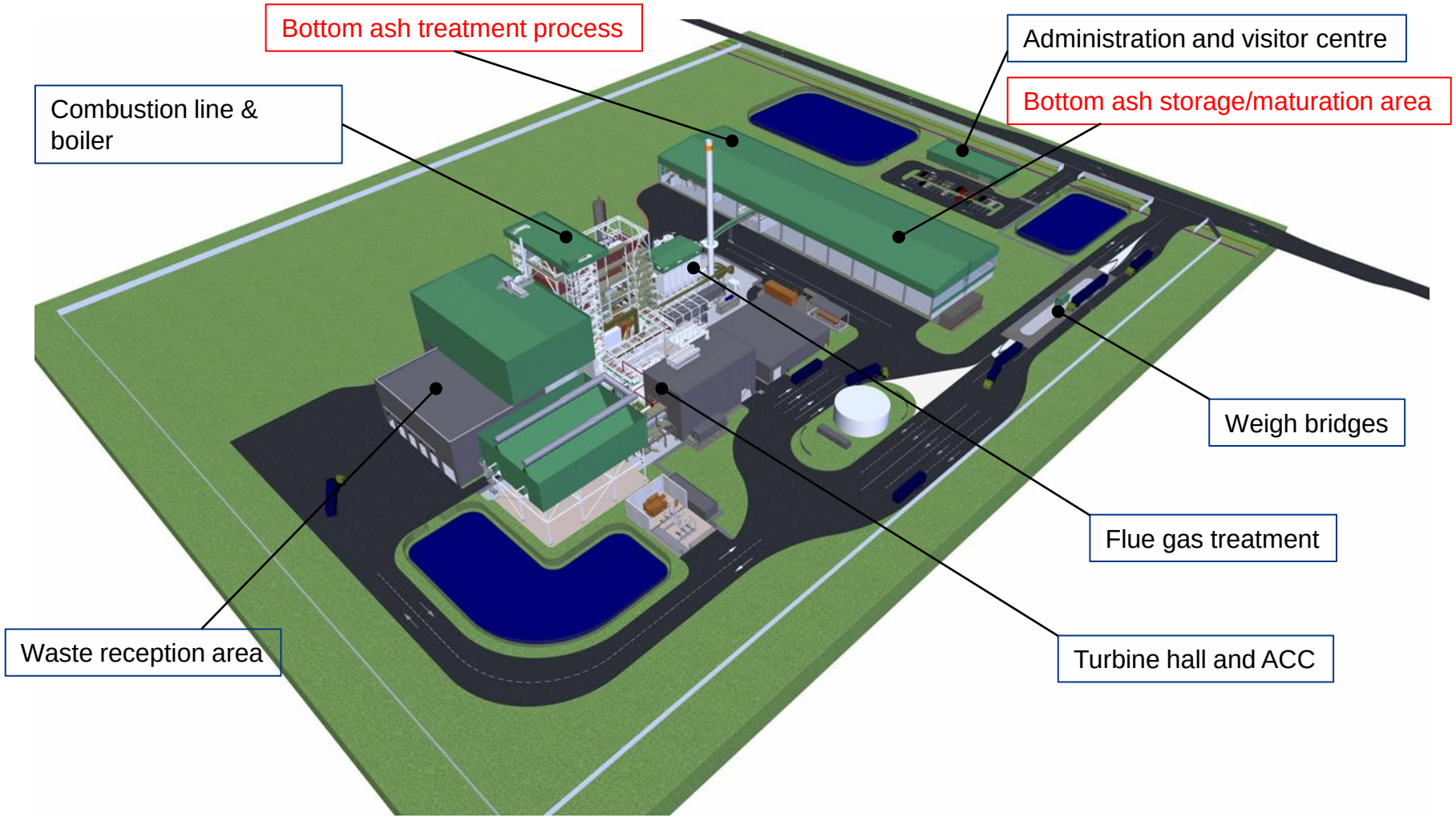
Let’s recycle bottom ash

Bottom ash treatment to metals and road aggregate

- Bottom ash treatment – wet and dry

Bottom Ash to Metals and Aggregate in Rockingham (based on UK concepts)



Strategy for Bottom Ash Aggregates
Replicate European experience in the local context

- Comply with UK and European Standard
- Products manufactured to a robust Quality Protocol
- Low embodied energy demand during production
- Supporting a sustainable future

Swiss focus on metal recovery with central bottom ash recycling plant; aggregate recycling is not an option for Swiss authorities

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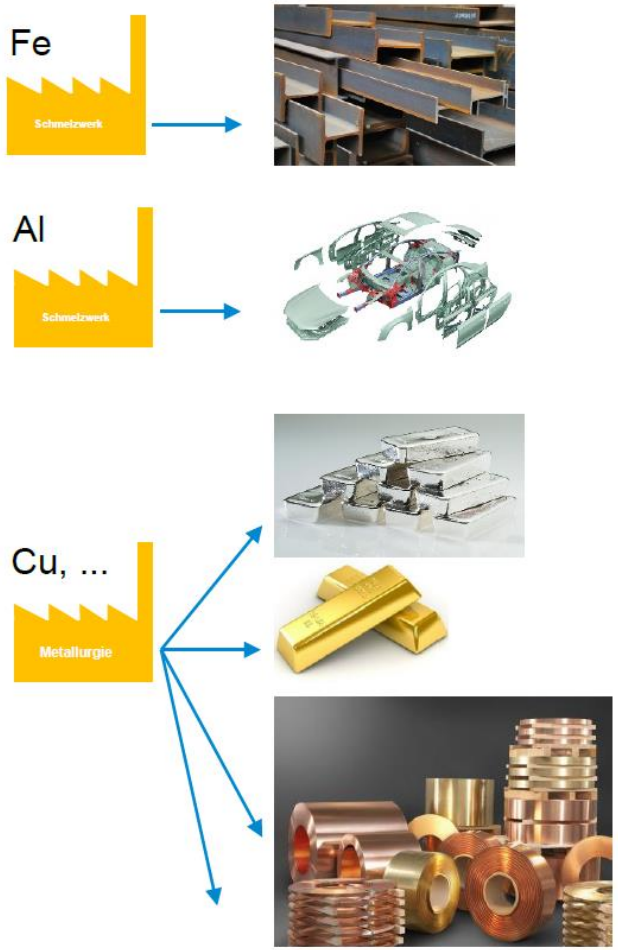
Aluminium > 0.2 mm

NE schwer > 0.2 mm



Reference: Dr. René Müller, "Zentrale Aufbereitungsanlage für Trockenschlacke", 27.. Mai 2016, ZAR Informationsveranstaltung

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Let’s recycle flue gas treatment residues

Carbonation of FGT Residue with Carbon Dioxide; Lower Mobility of Contaminants & Re-Use as Light-Weight & Carbon-Negative Building Material

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Reference: www.oco.co.uk

Urban mining from fly ash Swiss style – 99,995% zinc
Zero waste to landfill with highest circular economy impact

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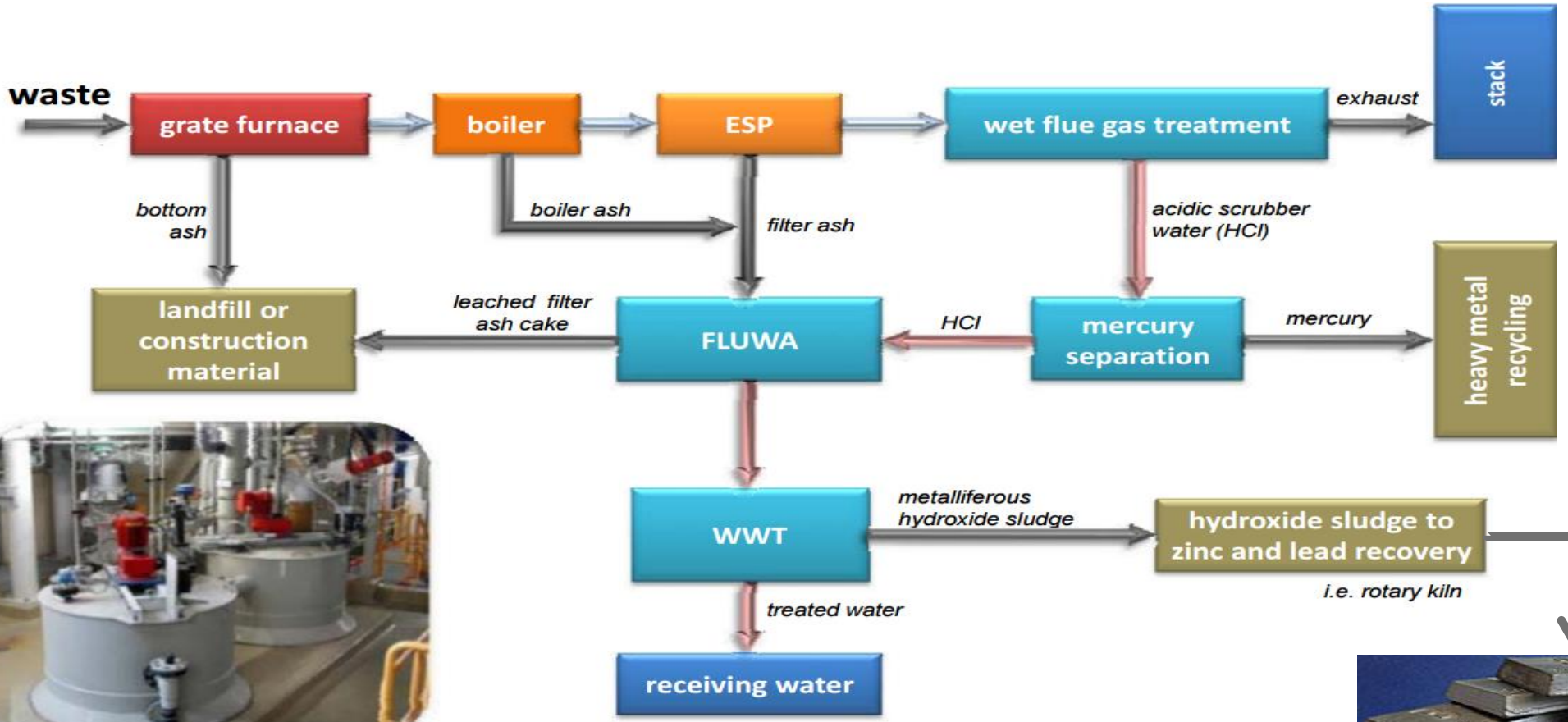

Reference: www.bsh.ch

With Ash2®Salt we can achieve 100% landfill diversion
Salarium, Sweden

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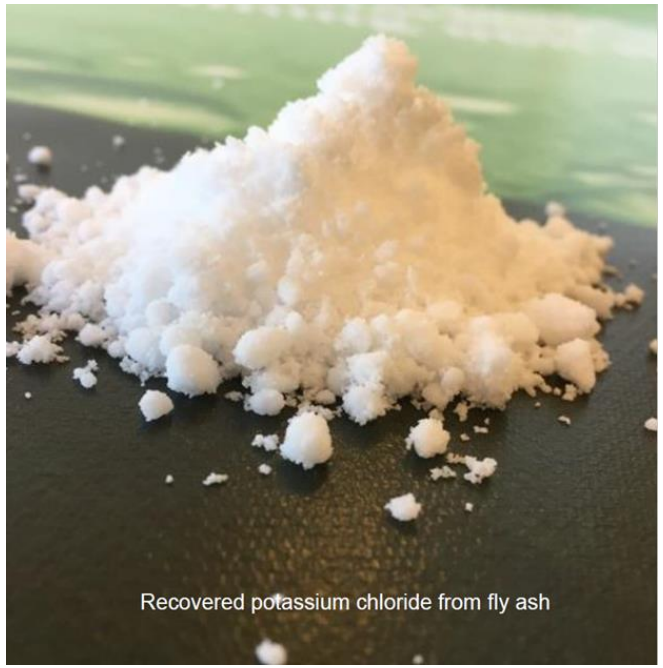
Client	**Ragn-Sells**
Start-up	**2022**
Technology	
Residue recovery	Ash2©Salt
Technical Data	
Residues	Flue Gas Treatment Residues & Fly Ashes
Capacity	130,000 t/y
Washing Fluid	128,000 m3/y
NaCl	7,000 t/y (salt)
KCl	3,500 t/y (salt)
$CaCl_2$	32,000 t/y (liquid)
$(NH4)_2SO_4$	800 t/y (solid)


Recovered potassium chloride from fly ash

- Washing of flue gas treatment residues to commercial salts
- Residue can replace sand in concrete
- Linear waste flow converted into a circular resource flow

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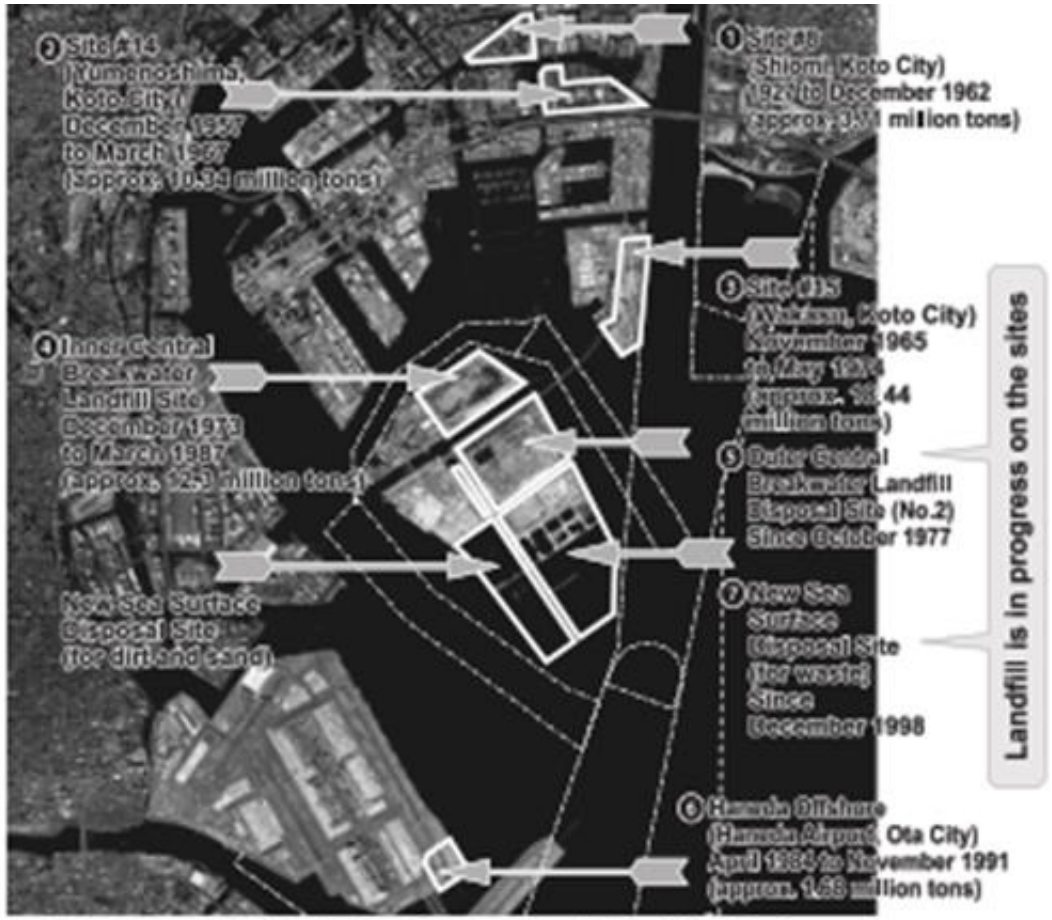
Some exotic reuse options

“Trash” to new airport in Tokyo – Land reclamation for Haneda Airport



Reference: Waste Report Tokyo23; downloaded 27 Aug 2019 from http://www.union.tokyo23-seisou.lg.jp.e.de.hp.transer.com/seiso/seiso/pamphlet/report/index.html

Reference: Japan Times; downloaded Aug 2019 from https://www.japantimes.co.jp/life/2017/02/18/environment/wasteland-tokyo-grows-trash/#.XWXBtHtS82w

Singapore Grows its Territory and Biodiversity at Semakau Landfill/Island with its EfW Residues

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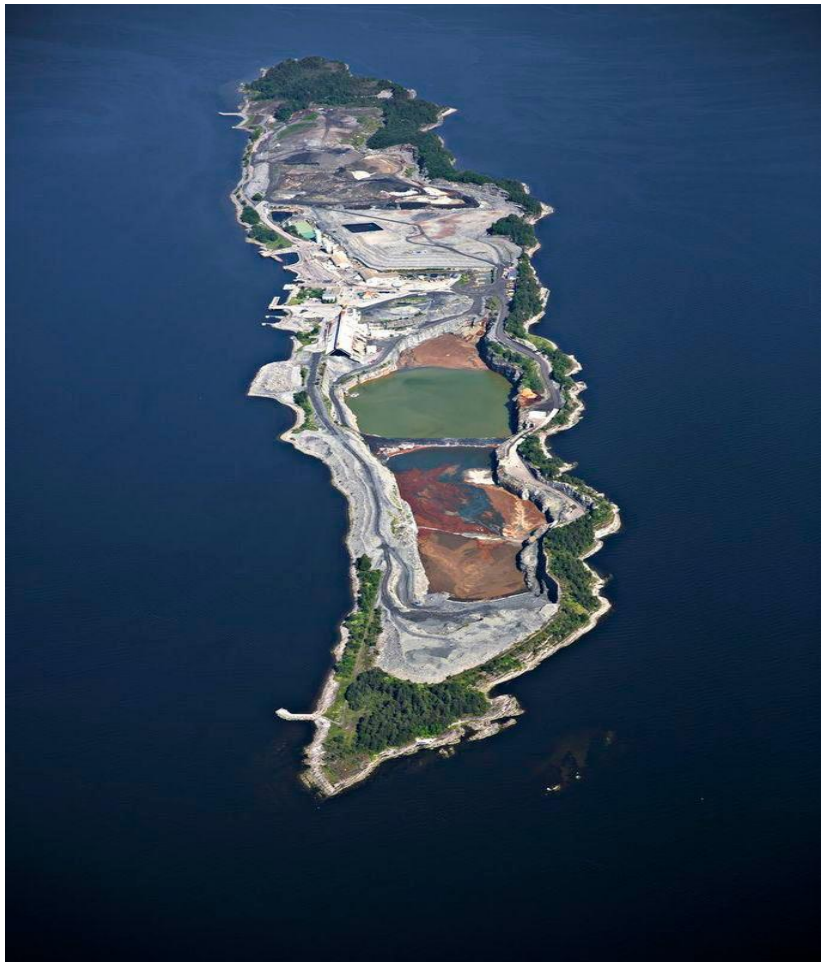
Reference: L.Hoshaw: Refuse Collects Here, but Visitors and Wildlife Can Breath Free, NY Times, Aug 15, 2011; downloaded 27 Aug 2019 from https://www.nytimes.com/2011/08/16/science/16landfill.html

Reference: A. Darhni: What Singapore Does With Its Garbage Is A Lesson For The World In How To Save The Planet, ScoopWhoop, Sep 22, 2011; downloaded 27 Aug 2019 from https://www.scoopwhoop.com/singapore-trash-island/

Re-use of hazardous flue gas residuals Norwegian style



- Langøya is located in Holmestrand fjord (Norway):
  - Consists of limestone with an age of 300 to 400 million years
  - Approximately 3 km long and 500 m wide
  - Limestone extraction for cement production up to 1985 left two craters totaling 9.3 mio cbm below sea level
- Waste treatment since 1985:
  - Treatment and final disposal of hazardous waste, inorganic industrial wastes, unearthed soil and sediments.
  - Fill large craters as rehabilitation work supported by Norwegian authorities
  - Accepts waste from Scandinavia & Northern Europe

Reference : Picture and information from www.noah.no (downloaded 15 Sep 2015)

Backfilling of underground salt mines in Germany with FGT Residues
Regarded as recycling as it protects communities on top of otherwise collapsing cavities

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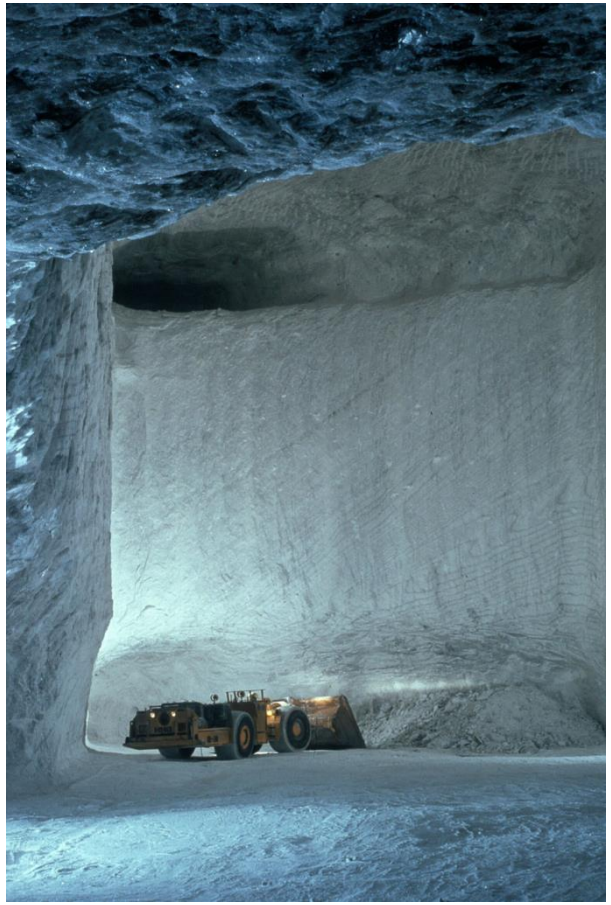

Reference : Pictures from www.ks-entsorgung.com (downloaded 16 Fep 2017)

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Conclusions

Summary of existing re-use options for ashes

- Bottom ash recycling:
  - Increased need for EfW with growth of multi-component materials
  - Metal recycling is good for environment and detoxifies bottom ash
  - Bottom ash aggregate recycling is business as usual and pushed to even better metal recovery
  - Move from special regulation to general building material standard

- Flue gas treatment residue recycling is country-specific:
  - Zero waste plus zinc (Switzerland)
  - Ash2©Salt (Sweden)
  - Solidification & landfilling (UK)
  - Carbonation and re-use (UK)
  - Backfill solutions (Germany, Japan, Singapore, Norway)

Specific Conclusions for Australia

- Bottom ash recycling is left to each State and its ability to move beyond landfill.
- States should adopt UK bottom ash framework and regulations

- Flue gas treatment residues will go to landfill or for re-use:
  - “as is”
  - solidified with cement (doubles the weight)
  - acid or neutral washed & extracted
  - carbonated with CO2 (OCO and others)

- Market as building aggregates and will then have to overcome the regulatory hurdle

- Residues to landfill would prevent the circular economy and drive up the gate fee by $50/t to $90/t

- Regulatory enabling of residue recycling is key for a sustainable & competitive EfW industry
- And, EfW is key for a competitive recycling and organics market as they have residues, too!

EfW – Kickstarting a nascent industry…
…. capable of adding 2 GW baseload capacity and 2,000 jobs

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East Rockingham RRF

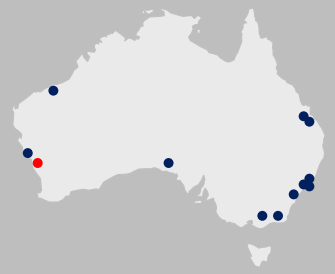
287ktpa
MSW diverted from landfill each year through pioneering Energy-from-Waste technology in Australia

600kt CO_2
Savings p.a. through landfill reduction and avoided methane emissions

$450m
Pioneering best-in-class technology, a first for Australia, utilising HZI, the world leader

28MW
Baseload renewable power at a capacity factor of more than 95%

AUSTRALIA'S WASTE OPPORTUNITY…



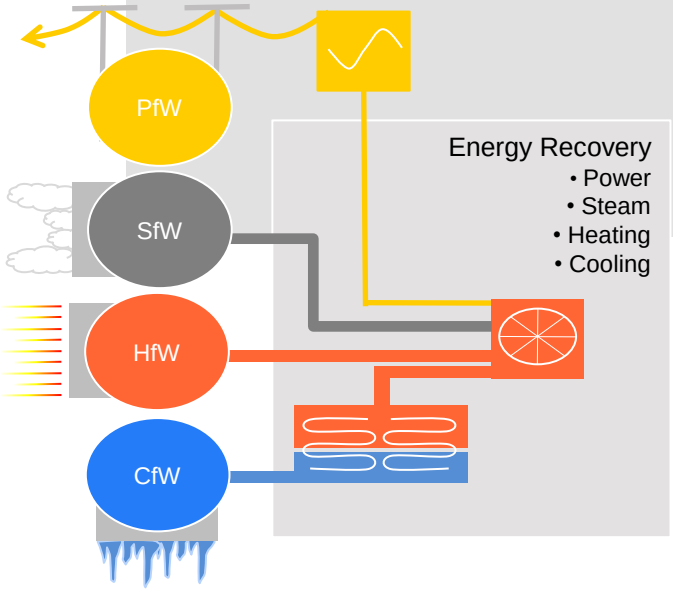
22 million tpa
Residual solid waste going to landfill across Australia

50+ plants
Could be developed to handle existing and future residual waste demand

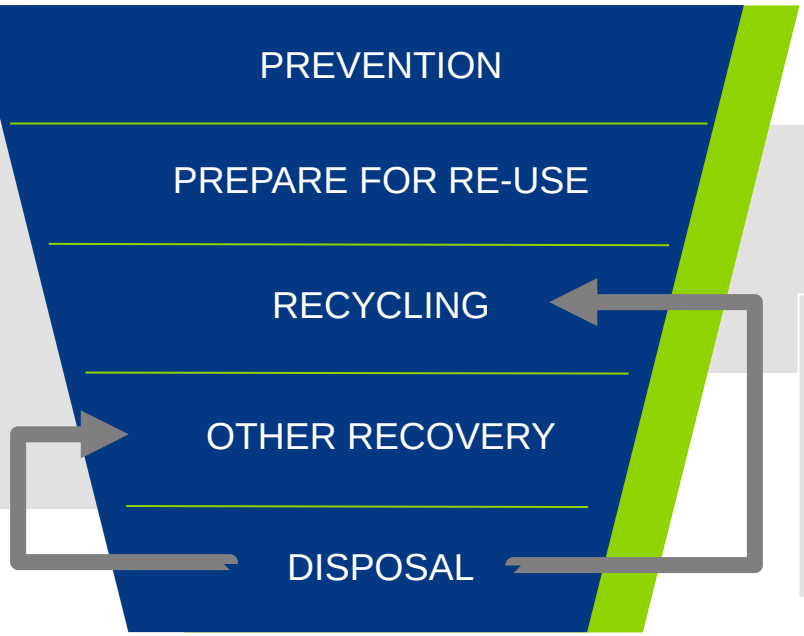
2,000MW
Baseload power capacity additions nationally with 50%+ renewable eligibility

«Waste hierarchy» beyond Energy from Waste

Not only
Energy-from-Waste …

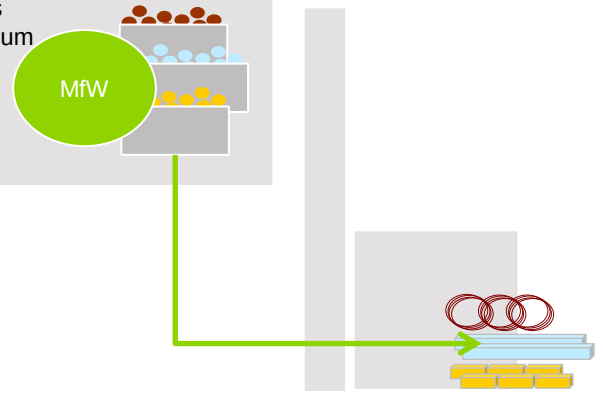


Energy Recovery
- Power
- Steam
- Heating
- Cooling



… but also
Material-from-Waste!

Aggregate, Metal & Salt Recovery
- Precious metal
- Ferrous
- Aluminium



Best Available Technology diverts 96% to 100% from landfill

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Waste is our Energy.
Engineering is our Business.
Sustainable Solutions are our Mission.

Check our References.