TECHNISCHE UNIVERSITÄT WIEN

Technical Aspects of Bottom Ash Treatment and Recovery of Valuable Materials – An Overview

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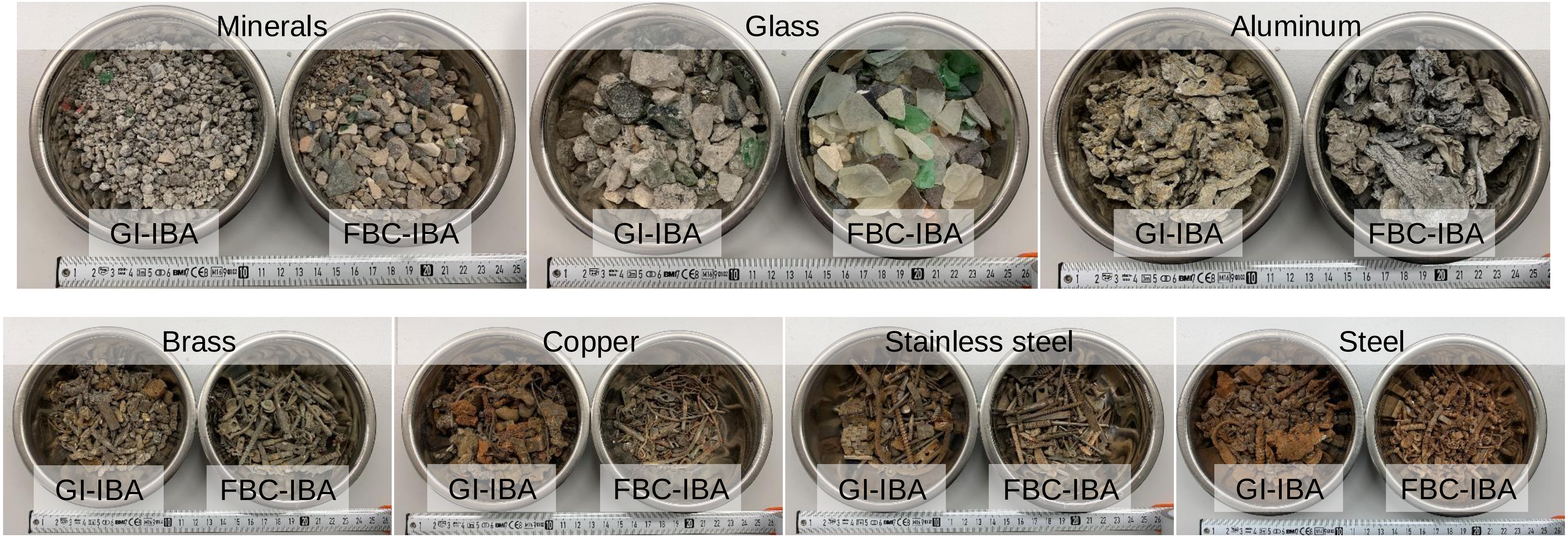
The effort of recycling Incinerator Bottom Ash (IBA)

What to consider…

- Waste input? *MSW only? Commercial waste? Bulky waste? Hazardous Waste? Mixture?*
- Incineration technology? *Grate incineration (GI), Fluidized Bed Combustion (FBC), Rotary kiln (RK)*
- IBA discharge? *Wet or dry?*
- Fractions to recover? *Minerals, metals, glass,…*
- Application of recovered materials? *Landfill, construction material, metal refining industry, glass industry*
- Market situation?
- Legal boundaries? *Is utilization of minerals outside landfills possible? Applications?*

These questions determine the design of the recycling process!

Effect of Incineration Technology on the Quality of Valuable Materials



Photos by Dominik Blasenbauer

Legal boundaries in the EU member states

Published in Blasenbauer et al., 2020

- IBA volumes in EU+CH, NO, UK - approx. 18 Mt/a; recycling rate 54 wt.%; range of recycling rate from 0 to 100 wt.%.
- Countries handle recycling autonomously → different material requirements
  - 6 different areas of application
  - 51 different parameters for total content, 36 parameters for leaching behavior
  - 9 different standards for evaluation of leaching behavior
- Barriers and drivers: HP 14 criterion, end of waste, restriction of landfilling for MSWI ash, uniform regulation at the EU level
- Clear regulation does not necessarily lead to high recycling rates

Blasenbauer, Dominik, Florian Huber, Jakob Lederer, Margarida J. Quina, Denise Blanc-Biscarat, Anna Bogush, Elza Bontempi, et al. „Legal situation and current practice of waste incineration bottom ash utilisation in Europe". *Waste Management* 102 (1. Februar 2020): 868–83. https://doi.org/10.1016/j.wasman.2019.11.031.

Legal boundaries in the EU member states

Austrian update

- Utilization outside landfills possible
- Requirements defined in the *Federal Waste Management Plan* (BMK, 2023) and *Technical guidelines for the use of waste as substitute raw materials in cement production plants (Republic of Austria, 2017)*
- Permitted areas of application:
  - Aggregates for concrete production → **NEW** from 2023
  - Bound and unbound base layers in road construction
  - Cement production process

BMK. „Bundesabfallwirtschaftsplan 2023 (Federal Waste Management Plan 2023)", 2023.
Republic of Austria. „Technische Grundlagen für den Einsatz von Abfällen als Ersatzrohstoffe in Anlagen zur Zementerzeugung (en: Technical guidelines for the use of waste as substitute raw materials in cement production plants)". Guideline. Vienna: Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, 2017.

Legal boundaries in the EU member states

Austrian update

Parameter	Unit	Road base layer	Concrete ≤10%*	Concrete ≤20%*	Cement production
Metal content					
Fe-metals	% DM	1	0.5	0.5	-
NFe-metals	% DM	0.8	0.4	0.4	-
Total content of harmful substances					
As	mg/kg DM	-	-	-	30
Cd	mg/kg DM	10	4	3	5
Co	mg/kg DM	-	-	-	250
Cr	mg/kg DM	800	500	400	500
Hg	mg/kg DM	-	-	-	0.7
Ni	mg/kg DM	300	200	200	500
Pb	mg/kg DM	900	600	500	500
Sb	mg/kg DM	-	-	-	30
Tl	mg/kg DM	-	-	-	3
TOC	% DM	1	1	1	-

*Percentage of recycled aggregates produced from IBA
L/S liquid to solid ratio; DM dry matter

Legal boundaries in the EU member states

Austrian update

Parameter	Unit	Road base layer	Concrete ≤10%*	Concrete ≤20%*
Leaching content of harmful substances (L/S 10, EN 12457-4)				
pH value	-	12	12	12
Electr. conductivity	-	To be measured	To be measured	To be measured
As	mg/kg DM	0.5	0.5	0.5
Cr	mg/kg DM	0.5	0.5	0.5
Cu	mg/kg DM	4	2	2
Mo	mg/kg DM	1	0.8	0.8
Ni	mg/kg DM	0.4	0.4	0.4
Pb	mg/kg DM	0.5	0.5	0.5
Sb	mg/kg DM	0.6	0.6	0.6
Chloride (as Cl)	mg/kg DM	3000	2500	2000
Sulphate (as SO_4)	mg/kg DM	5000	5000	3000

*Percentage of recycled aggregates produced from IBA
L/S liquid to solid ratio; DM dry matter
EN. „DIN EN 12457-4:2002 Characterization of waste - Leaching - Compliance test for leaching of granular waste materials and sludges ó Part 4: One stage batch test at a liquid to solid ratio of 10 l/kg for materials with particle size below 10 mm (without or with size reduction)“;, 2002.

Treatment of IBA

Standard treatment:

- Dry treatment
- Screening
- Fe-metals separation, NFe-metals separation
- Outputs:
  - Minerals/glass → landfill
  - Metals → recycling

Advanced treatment:

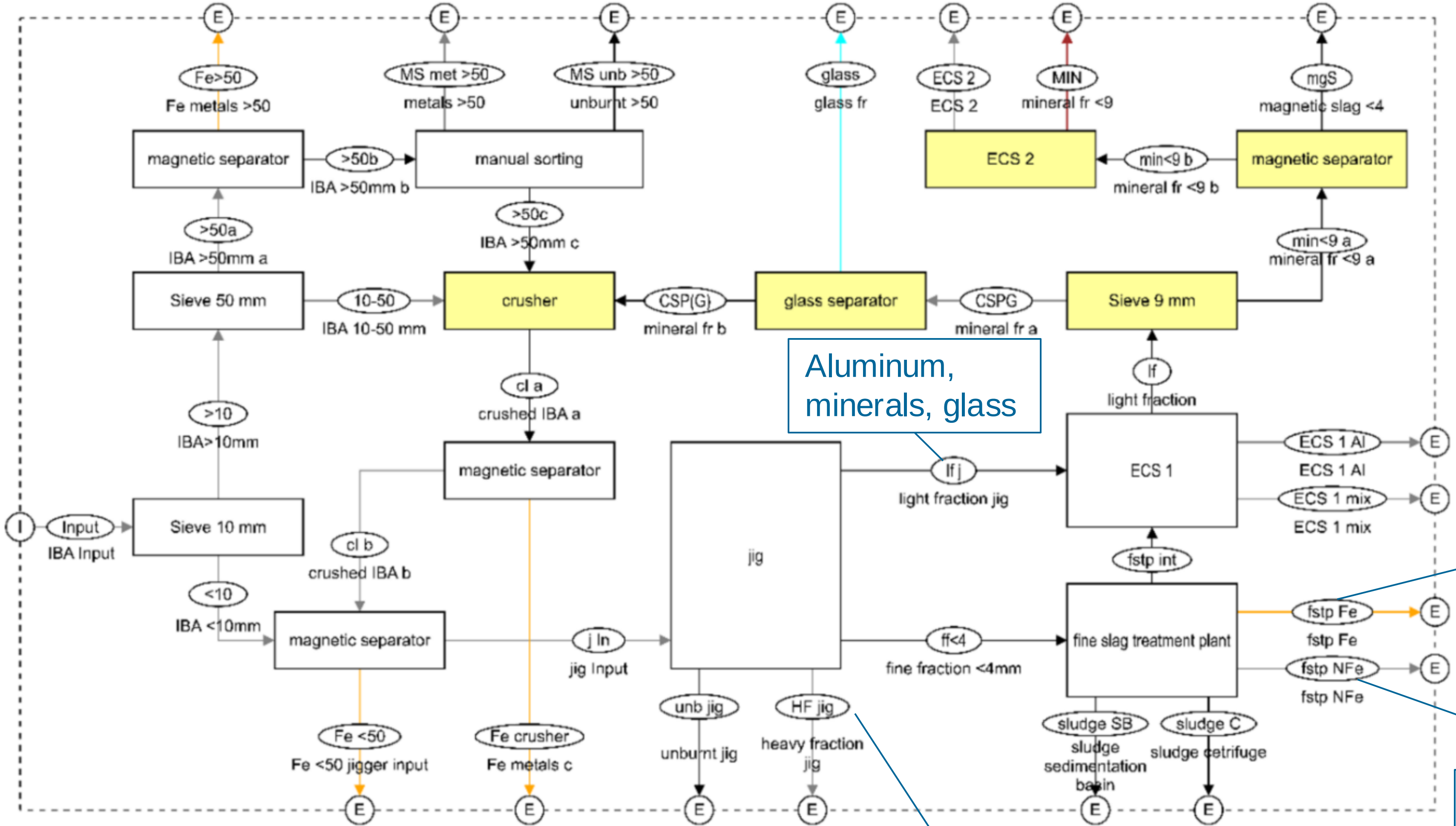
- Wet treatment
- Density separation
- Multistep screening
- Comminution
- Multistep Fe- and NFe-metal separation
- Outputs:
  - Coarse minerals → recycling
  - Fine minerals → landfill
  - Glass → recycling
  - Metals → recycling

Advanced treatment facility

- Nominal capacity: 30 t/h
- Location: Lower Austria, Austria
- Input: GI- and FBC-IBA
- Outputs:
  - Aggregates 63 µm to 2 mm
  - Aggregates 2 mm to 8 mm
  - Glass >9 mm
  - Fe-metals
  - NFe-metals
  - NFe-fine-concentrate
  - Fines <63 µm
  - Unburnt materials

Photo by Simon Mika

Advanced treatment facility



Aluminum, minerals, glass

Fe oxides

Metallic heavy NFe concentrate

Fe-metals, brass, copper

Flow chart from: Mühl, Julia, Simon Hofer, Dominik Blasenbauer, und Jakob Lederer. „Recovery of aluminum, magnetic ferrous metals and glass through enhanced industrial-scale treatment of different MSWI bottom ashes". *Waste Management* 190 (15. Dezember 2024): 557–68. https://doi.org/10.1016/j.wasman.2024.10.025.

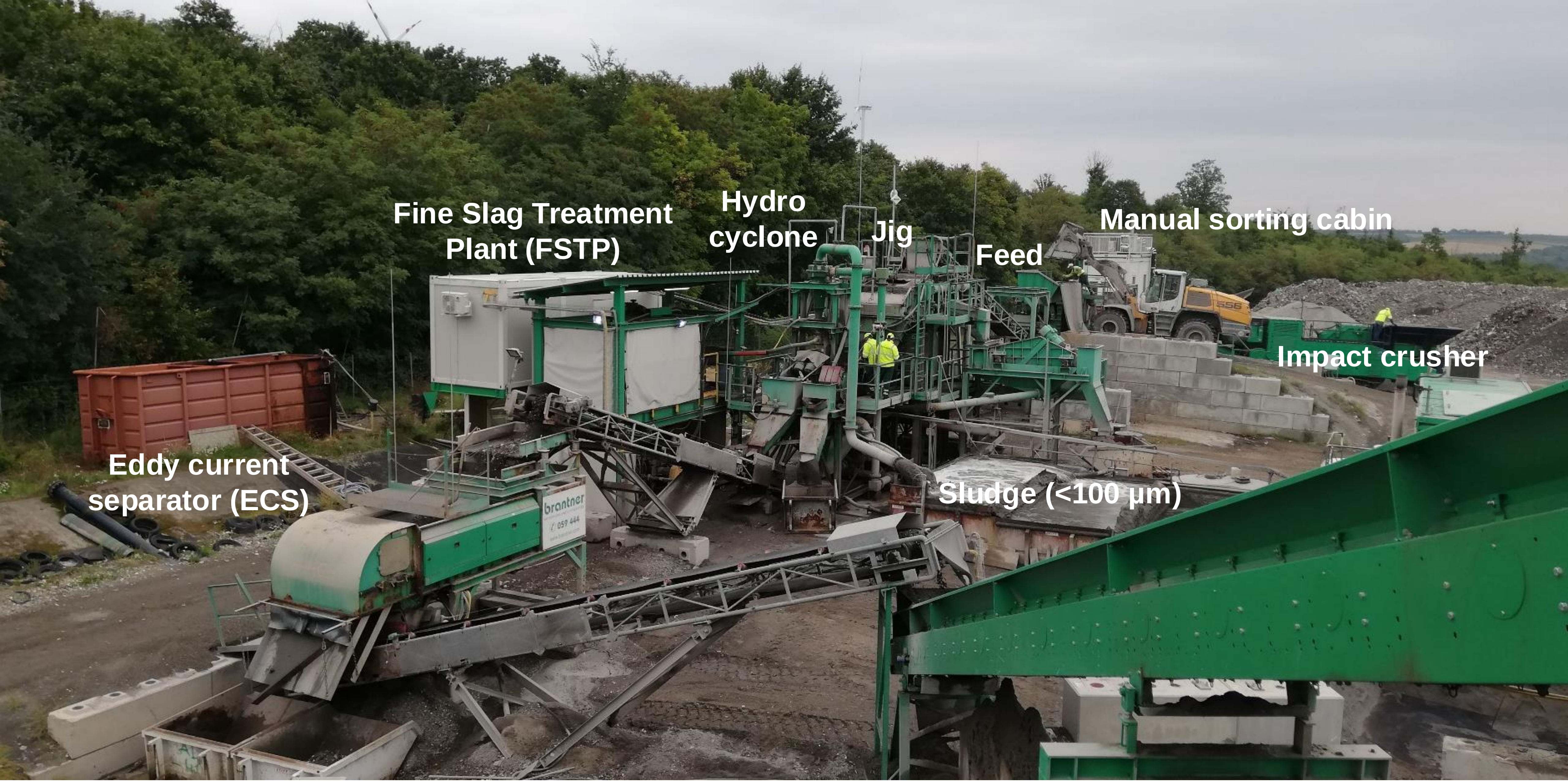


Photo by Simon Mika

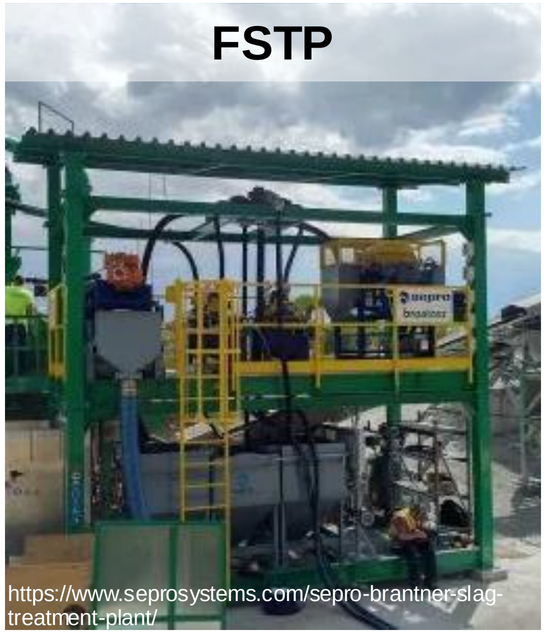
Advanced treatment facility

Fine Slag Treatment Plant: 63 µm to 2 mm

<u>Consists of three gravity concentration devices:</u>

- **Slot separator**
  - High material volume
  - Rough separation of heavy and light particles
- **Shaking table**
  - Produces high-grade metal concentrate
- **Falcon Concentrators**
  - Recovers fine metal particles from low-concentrate feeds (shaking table tailings and slot separator light fraction)
  - Transfers them back to the shaking table

FSTP



https://www.seprosystems.com/sepro-brantner-slag-treatment-plant/

Falcon Concentrator

https://www.seprosystems.com/wp-content/webp-express/webp-images/uploads/2024/07/5.-Product-Featured-544-x-569_Falc-C-3-Re.jpg.webp

Shaking table

Fine metal concentrate

Two lower photos by Simon Mika

Advanced treatment facility

Sludge

Sludge treatment:

- Separation of particles <63 µm with hydro cyclone
- Serves as a sink for salts and heavy metals
- Landfill for non-hazardous waste

Photos by Julia Mühl

Photo by Simon Mika

Advanced treatment facility

Minerals 2-8 mm and glass >9 mm

Photos by Julia Mühl

Goal
Utilization as aggregate in concrete production

Challenges
- Limit values for heavy metals ✓(→ advanced wet treatment) (Lederer et al., 2024)
- Achievement of concrete strengths ✓(Lederer et al., 2024)


Photos by Felix Feher

Photo by Julia Mühl

Goal
Utilization in the packaging glass industry

Challenges
- Very strict limits for metal content (2-3 **g**/t !) ✗
- Lead glass, ceramics, lab-glass ware ✓

However, utilization in the **foam glass industry** is currently possible!

Lederer, J., Hron, J., Feher, F., Hofer, S., Mühl, J., Zeman, O., & Bergmeister, K. (2024). Evaluation of standard concretes containing enhanced-treated fluidized-bed waste incineration bottom ash as manufactured aggregate. *Case Studies in Construction Materials*, e03759. https://doi.org/https://doi.org/10.1016/j.cscm.2024.e03759

Advanced treatment facility

Summary

- Recovery of > 95% of aluminum and magnetic ferrous metals > 4 mm from GI- and FBC-IBA (Mühl et al., 2024)
- Recovery of 72% of glass > 4 mm in the FBC-IBA (Mühl et al., 2024)
- Recovery of NFe-metal concentrates to particle sizes of approx. 100 µm.
- Minerals 2-8 mm comply with requirements for concrete production.
  - Complies with EN 12620 *Aggregates for Concrete*
  - Complies with Austrian Federal Waste Management Plan
  - CPR certified
  - End-of-waste in concrete mixing facility
  - 20% replacement of natural aggregates possible

Mühl, Julia, Simon Hofer, Dominik Blasenbauer, und Jakob Lederer. „Recovery of aluminum, magnetic ferrous metals and glass through enhanced industrial-scale treatment of different MSWI bottom ashes“. *Waste Management* 190 (15. Dezember 2024): 557–68. https://doi.org/10.1016/j.wasman.2024.10.025.

Advanced treatment facility

Summary

- Minerals 63 µm-2 mm:
  - Planned to be utilized in binding agent production (e.g. cement)
  - Technically feasible, however, currently not economically feasible
- Advanced treatment significantly reduces landfill fraction (<63 µm):
  - GI-IBA: 11% (dry matter) of the input to treatment to landfill (Mühl et al., 2024)
  - FBC-IBA: 5% (dry matter) of the input to treatment to landfill (Mühl et al., 2024)

Mühl, Julia, Simon Hofer, Dominik Blasenbauer, und Jakob Lederer. „Recovery of aluminum, magnetic ferrous metals and glass through enhanced industrial-scale treatment of different MSWI bottom ashes“. *Waste Management* 190 (15. Dezember 2024): 557–68. https://doi.org/10.1016/j.wasman.2024.10.025.

What is next?

Developments on the advanced recovery of valuables from IBA

- Electrodynamic fragmentation
  - Fragmentation of agglomerates along the material boundaries between electrodes.
  - Industrial application in Swiss incineration facility (Weh, 2018).
  - Energy consumption of 6 kWh/t (Weh, 2018).
- Improved metal recovery: fine slag treatment → recovery of metals down to 20 µm
- Sensor-based sorting: glass recovery (VIS sensors), metal recovery and sorting (XRF, LIBS, induction sensors)
- Utilization of the fines by wet chemical treatment (acidic extraction, biochemical leaching, etc.) (Quicker and Stockschläder, 2016)

Weh, Alexander. „Industrial Application of Electrodynamic Fragmentation to Bottom Ashes at the KVA Fribourg, Switzerland“, 2018. https://books.vivis.de/wp-content/uploads/2023/01/2018_MNA_130-151_Weh.pdf.
Quicker, Peter, and Jan Stockschläder. „Möglichkeiten einer ressourcenschonenden Kreislaufwirtschaft durch weitergehende Gewinnung von Rohstoffen aus festen Verbrennungsrückständen aus der Behandlung von Siedlungsabfällen“, 2016. https://www.umweltbundesamt.de/publikationen/moeglichkeiten-einer-ressourcenschonenden-0.

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Recent publications on characterization of IBA and treatment processes at TU Wien

Huber, Florian, Dominik Blasenbauer, Philipp Aschenbrenner, and Johann Fellner. „Chemical composition and leachability of differently sized material fractions of municipal solid waste incineration bottom ash“. *Waste Management* 95 (15. Juli 2019): 593–603. https://doi.org/10.1016/j.wasman.2019.06.047.

Huber, Florian, Dominik Blasenbauer, Philipp Aschenbrenner, and Johann Fellner. „Complete determination of the material composition of municipal solid waste incineration bottom ash“. *Waste Management* 102 (1. February 2020): 677–85. https://doi.org/10.1016/j.wasman.2019.11.036.

Huber, Florian. „Modelling of material recovery from waste incineration bottom ash“. *Waste Management* 105 (15. March 2020): 61–72. https://doi.org/10.1016/j.wasman.2020.01.034.

Blasenbauer, Dominik, Florian Huber, Jakob Lederer, Margarida J. Quina, Denise Blanc-Biscarat, Anna Bogush, Elza Bontempi, et al. „Legal situation and current practice of waste incineration bottom ash utilisation in Europe“. *Waste Management* 102 (1. February 2020): 868–83. https://doi.org/10.1016/j.wasman.2019.11.031.

Blasenbauer, Dominik, Florian Huber, Julia Mühl, Johann Fellner, and Jakob Lederer. „Comparing the quantity and quality of glass, metals, and minerals present in waste incineration bottom ashes from a fluidized bed and a grate incinerator“. *Waste Management* 161 (15. April 2023): 142–55. https://doi.org/10.1016/j.wasman.2023.02.021.

Mühl, Julia, Stefan Skutan, Gerhard Stockinger, Dominik Blasenbauer, and Jakob Lederer. „Glass Recovery and Production of Manufactured Aggregate from MSWI Bottom Ashes from Fluidized Bed and Grate Incineration by Means of Enhanced Treatment“. *Waste Management* 168 (1. August 2023): 321–33. https://doi.org/10.1016/j.wasman.2023.05.048.

Lederer, Jakob, Johannes Hron, Felix Feher, Simon Mika, Julia Mühl, Oliver Zeman, and Konrad Bergmeister. „Evaluation of standard concretes containing enhanced-treated fluidized-bed waste incineration bottom ash as manufactured aggregate“. *Case Studies in Construction Materials* 21 (1. December 2024): e03759. https://doi.org/10.1016/j.cscm.2024.e03759.

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