Separating brominated plastics from e-waste

E-Reciklaža 2010 experience in Serbia

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12 November 2026

E-Reciklaža 2010

Since 2010

Collection, transport and recycling of electrical and electronic waste in the Republic of Serbia

17,000

tonnes of e-waste annually

Company-reported annual operating volume

Our existing treatment capabilities

MEWA

German technology for
refrigeration equipment treatment

Main sources of the plastic stream

CRT and LCD televisions
Large household appliances
Small household appliances
Refrigerators

The challenge in the plastic stream

Legacy flame retardants can return to use through recycled plastics

Project objective	Separate the brominated plastic fraction after e-waste treatment.
Environmental purpose	Keep POP-contaminated material out of further recycling and reuse.

The scale of the opportunity

1,570 t

plastic output per year

5–30%

estimated brominated fraction

78.5–471 tonnes per year

Study-based range, pending operational validation. This is plastic mass, not PBDE mass.

International project partners

Yale University

UNIDO

Cleaner Production Centre of Serbia
Faculty of Technology and Metallurgy,
University of Belgrade

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Plastic samples analysed in Japan

National Institute for Environmental Studies (NIES), Japan

30 samples collected in 2024
Input plastics and output flakes

XRF: bromine content
FTIR: polymer type
GC/MS: flame retardants

Preliminary study.
Input and output samples were unpaired.











Evidence supporting the need for separation

Sample ID	Sample	Colour	Polymer	Br (mg/kg)
SRB24-01	LCD TV	Black	PS	1.0
SRB24-02	**CRT TV**	**Gray**	**PS**	**600**
SRB24-03	CRT monitor	Light gray	ABS	<LOD
SRB24-04	Printer	White	PC	3.0
SRB24-07-07	**Mixed output flake**	**Black**	**PS**	**5,800**

GC/MS confirmed PBDEs in the CRT sample. The output flake contained some PBDEs, with most bromine attributed to DBDPE and TTBP-TAZ.

Table excerpt: 2024 samples. Br = total bromine. LOD = limit of detection. Preliminary results.

What the laboratory results mean

600 mg/kg

Input CRT casing, PS
PBDEs confirmed by GC/MS

5,800 mg/kg

Output PS flake
PBDEs, DBDPE and TTBP-TAZ

Brominated flame retardants were present in the output plastic.
The findings support separation before further recycling.

Preliminary findings, not final results

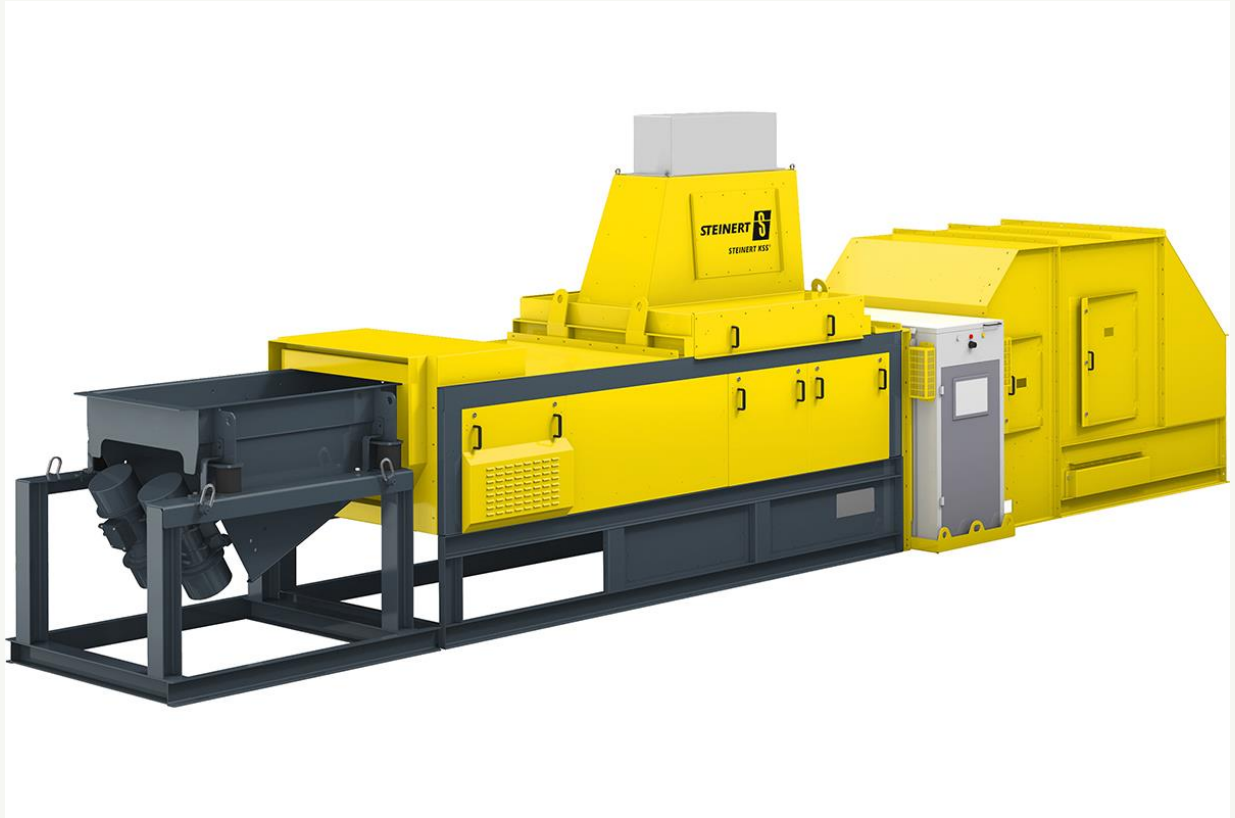
The actual share of brominated plastics and separation performance will be established through routine sorting, sampling and analysis.

Values show total bromine in individual samples. Unpaired samples do not measure treatment efficiency.

The STEINERT separation system

German manufacturer

Three sensors in one separator



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Three sensors in one separator

Sensor	Function
XRT / XT	X-ray transmission: differences in atomic density
C	Colour camera: colour detection
L	3D laser: shape and size detection

Commissioning in late October 2026

The technology is now in place

Next phase: routine operation
and verification of the separated fractions

The study’s 5–30% range remains to be tested in practice.

Programme support and the business case

Barrier	High transition costs and the cost of suitable separation technology.
Programme contribution	Partner commitment helped turn a technical need into installed equipment.
Expected business value	Better control of plastic quality and opportunities for further development.

Financial returns and additional investment remain to be assessed using operating data.

Financing beyond GreenChem

Investment barrier	High technology costs and uncertain commercial returns can prevent adoption.
GreenChem support	The programme enabled E-Reciklaža 2010 to obtain advanced separation technology.
Long-term financing	An effective “polluter pays” system, established by the state, is essential to finance sustainable operation and further development.

E-Reciklaža expects such a system in Serbia to support sustainable recycling and the practical implementation of green chemistry.

National priorities and regulatory readiness

National context	Serbia launched a review and update of its Stockholm Convention NIP in September 2026.
Project contribution	Industrial capability to separate potentially POP-contaminated plastics.
Industry perspective	Operating data can inform national planning and future technical requirements.

E-Reciklaža aims to prepare for evolving requirements and contribute practical industry experience.

Stricter PBDE limits in 2027

Serbia is a Party to the Stockholm Convention and implements its bans and restrictions on persistent organic pollutants (POPs).

Recovered-material use	Sum-PBDE limit	Serbia: new limit	EU: new limit
Mixtures and articles	**350 to 200 mg/kg**	30 Dec 2027	30 Dec 2027
Toys and childcare products	**350 to 10 mg/kg**	17 Dec 2027*	17 May 2027

New STEINERT equipment strengthens readiness for stricter Serbian and EU market requirements, supported by analysis of output quality.

*Date in the supplied Serbian text differs from the EU date. Limits concern the sum of five listed PBDEs, not total bromine. Food-contact materials are outside these derogations.

Conditions for wider industrial adoption

Cooperation	Committed partners and trust sustained the work through commissioning.
Policy dialogue	Open discussion of operational barriers and workable requirements.
Investment conditions	Access to finance, predictable rules and viable management of separated material.

Recommendations for wider uptake, based on the company's project experience

What we will establish in practice

Material quantities	Actual brominated fraction and differences between incoming waste streams.
Separation performance	Sampling and analysis of output quality and material losses.
Operating business case	Treatment costs, value of recovered plastics and management of the separated fraction.

Why the project succeeded

E-Reciklaža 2010, Yale University and UNIDO

Cleaner Production Centre
Faculty of Technology and Metallurgy, University of Belgrade

Determination, joint work and trust

Together, the partners demonstrated a path from a pilot project to a concrete industrial result that will benefit the wider community.

E•RECIKLAŽA
Reciklaža električnog i elektronskog otpada

International cooperation. A concrete industrial result.

Technology to help keep contaminated plastics out of the material cycle

Thank you
Igor Petrović, E-Reciklaža 2010