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Recycling of High Performance Polymers from Electro(nic) Scrap

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Are plastics a resource of valuable materials in WEEE ?

Polymer types , Challenges, thermal treatment

Recycling options

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- Current research

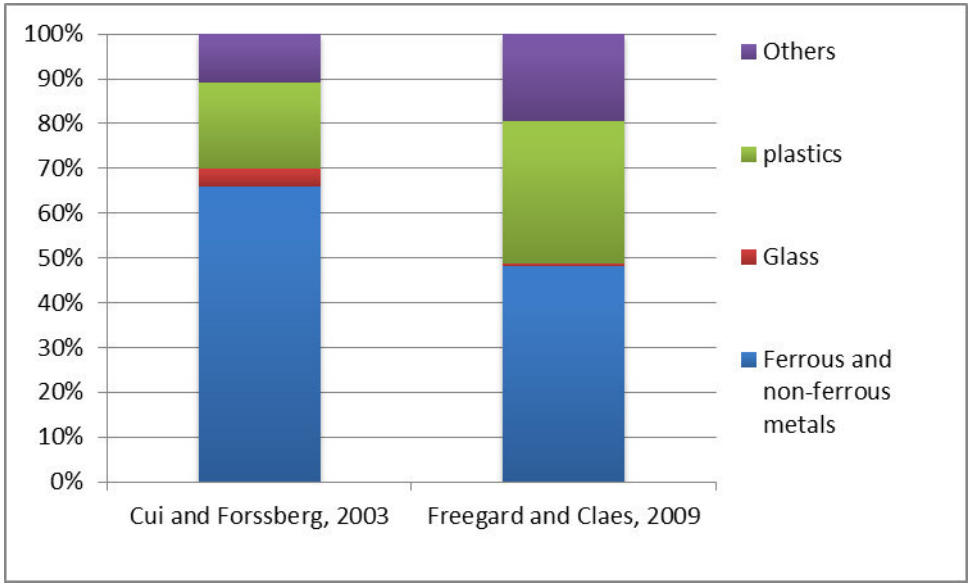
Most recent results

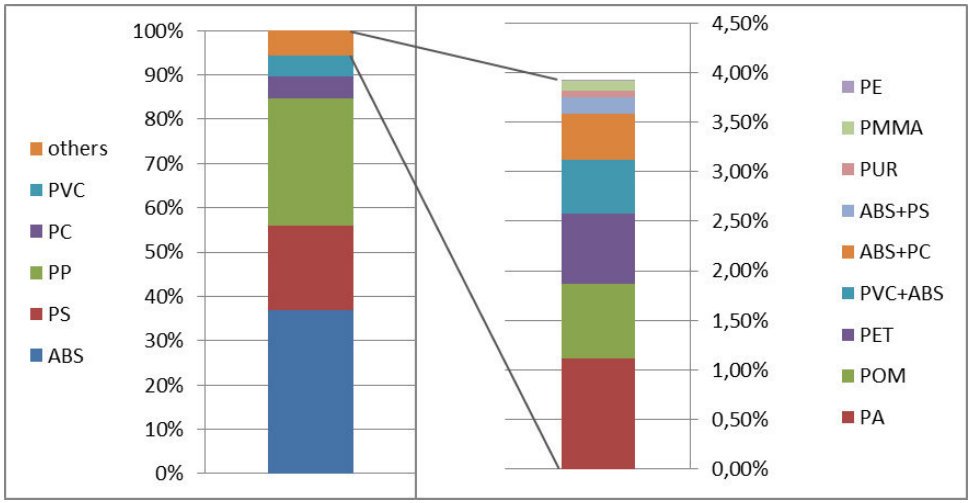
- Process optimisation
- Properties of recycled material
- Economics

Conclusions

Plastics in WEEE

- Plastic share of WEEE rises
- ABS, PS and PP are the dominating polymer types
- Cost of virgin PP, PS and ABS range from 1-2 €/kg
- Separation / recovery of plastics from WEEE is not state of the art
- Dismantling fractions
- Plastics account for 80% in shredder residues





Dimitrakakis, Janz, Bilitewski, Gidarakos (2009)

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Challenge WEEE plastic

Dust / Dirt / adhesives / heavy metals / Condensators (PCB)

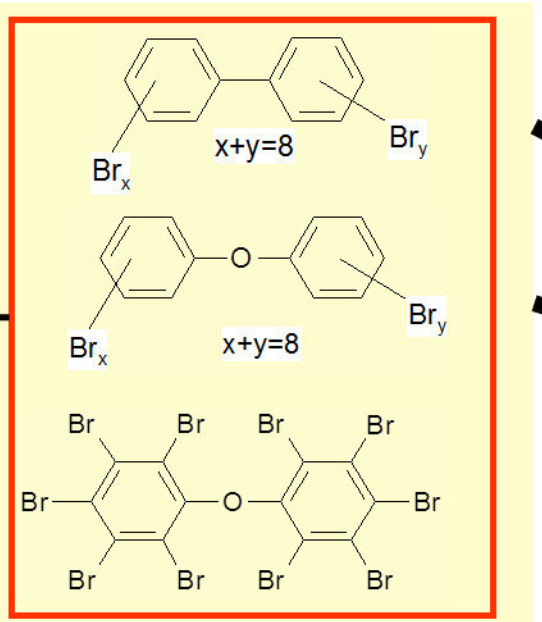
Mix of polymers

Separation / recovery of plastics from WEEE is not state of the art

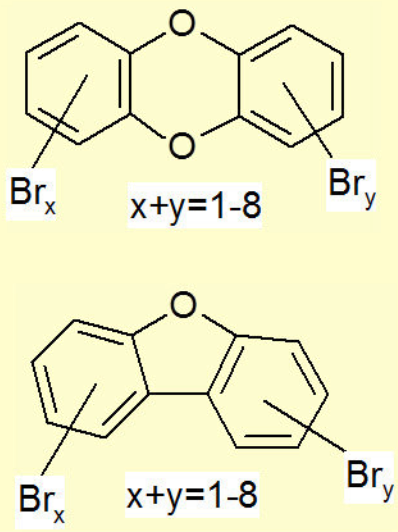
- Variety of plastic rich dismantling fractions
- Amount and shape of plastic rich shredder residues vary with applied technology

Challenge Brominated flame retardants (BFR) - General

RoHS:
0,1%



PBDD/F



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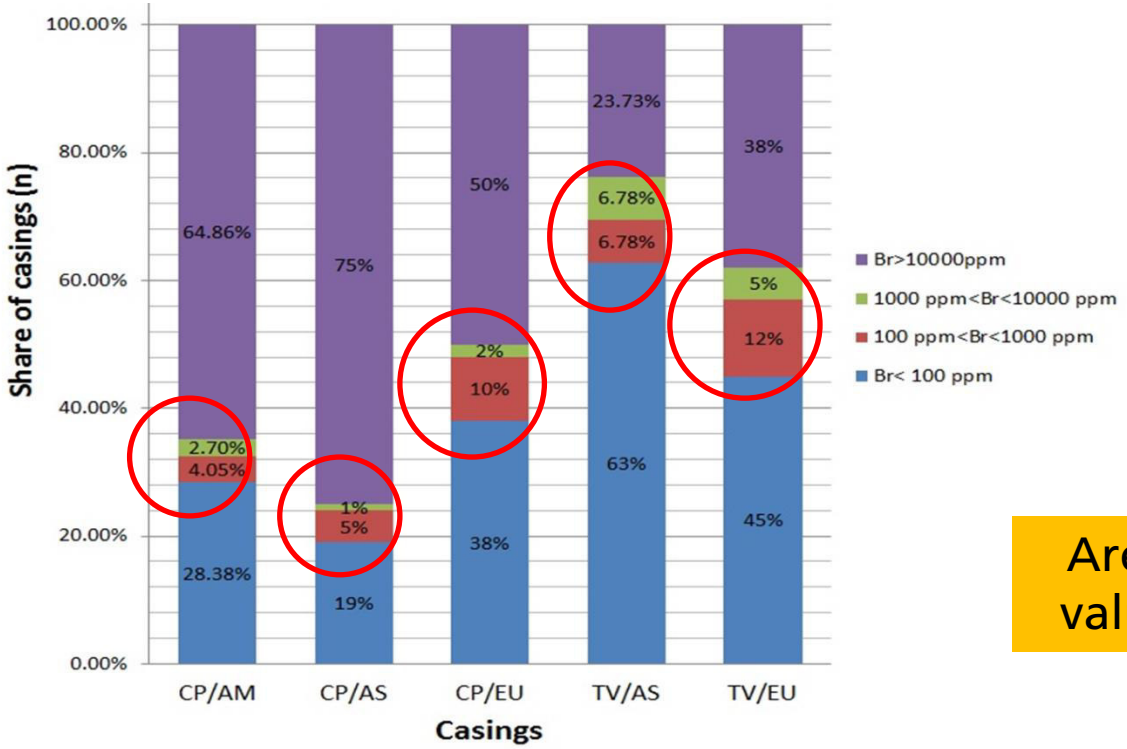
Challenge BFR – Is it still a problem ?

- No PBB anymore and decreasing amounts of OctaBDE
- Recycling practise makes no difference between BFR and PBDE
- Recent data on BFR in WEEE plastics sampled in Nigeria
  → still high shares of BFR materials and high share of DecaBDE



Are WEEE plastics a valuable ressource ?

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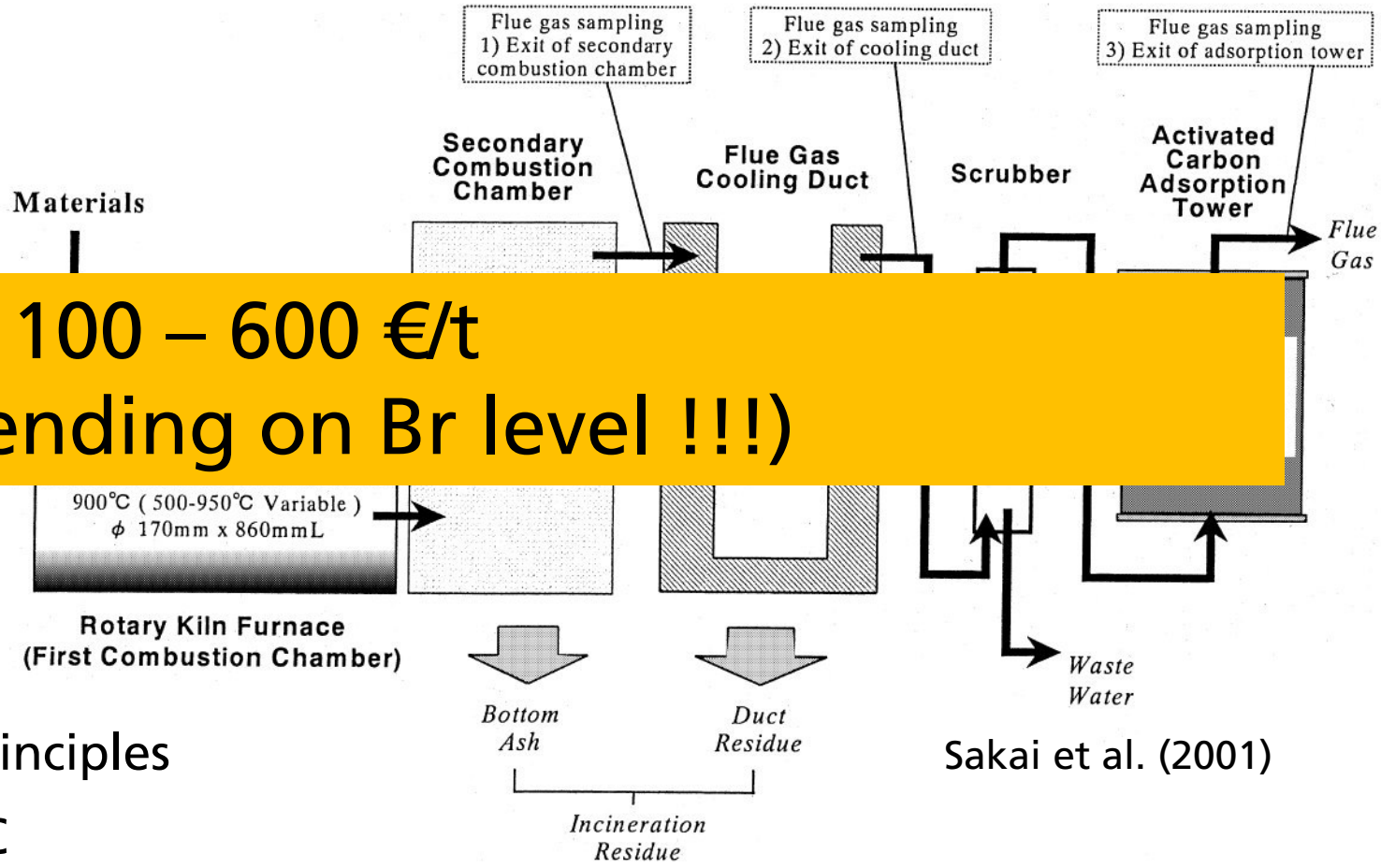
Thermal treatment BAT/BEP



Cost: 100 – 600 €/t
(depending on Br level !!!)

Sakai et al. (2001)

Important principles

- 2 s > 850°C
- Secundary combustion chamber
- Rapid cooling in order to avoid de-novo synthesis of dioxins/furans

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Thermal treatment in developing countries

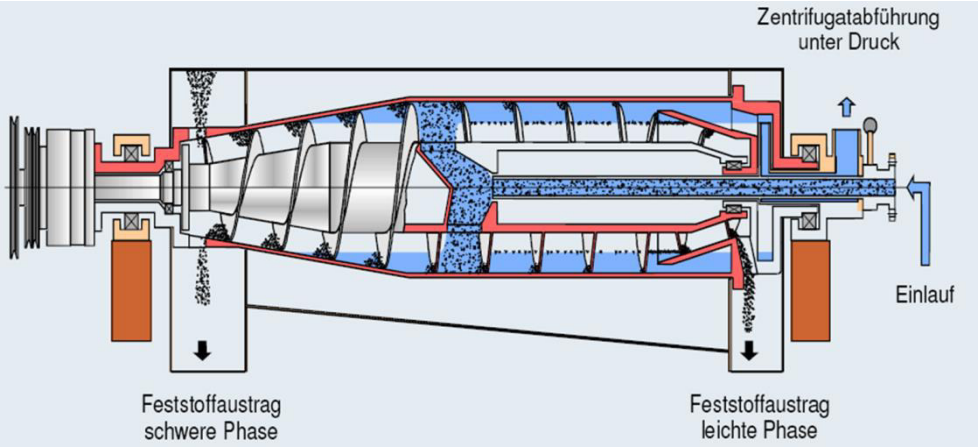
Low-tech incineration provides

- no T control
- no secundary combustion zone
- no fast cooling device

- High emissions into air, soil and water
- High exposure of workers towards BFR, PXDD/F and heavy metals

Recycling options – Cherry picking (BFR free)

- Separation of BFR containing polymers (e.g. by density or X-ray):
  → BFR elimination from TV sets >95%.
- Fractions with low BFR level can be separated into +/- pure polymer fractions (NIR, Laser, electrostatic)
- These provide good quality and RoHS compliance
- Disadvantage:
  BFR rich fraction needs treatment and is a cost factor.

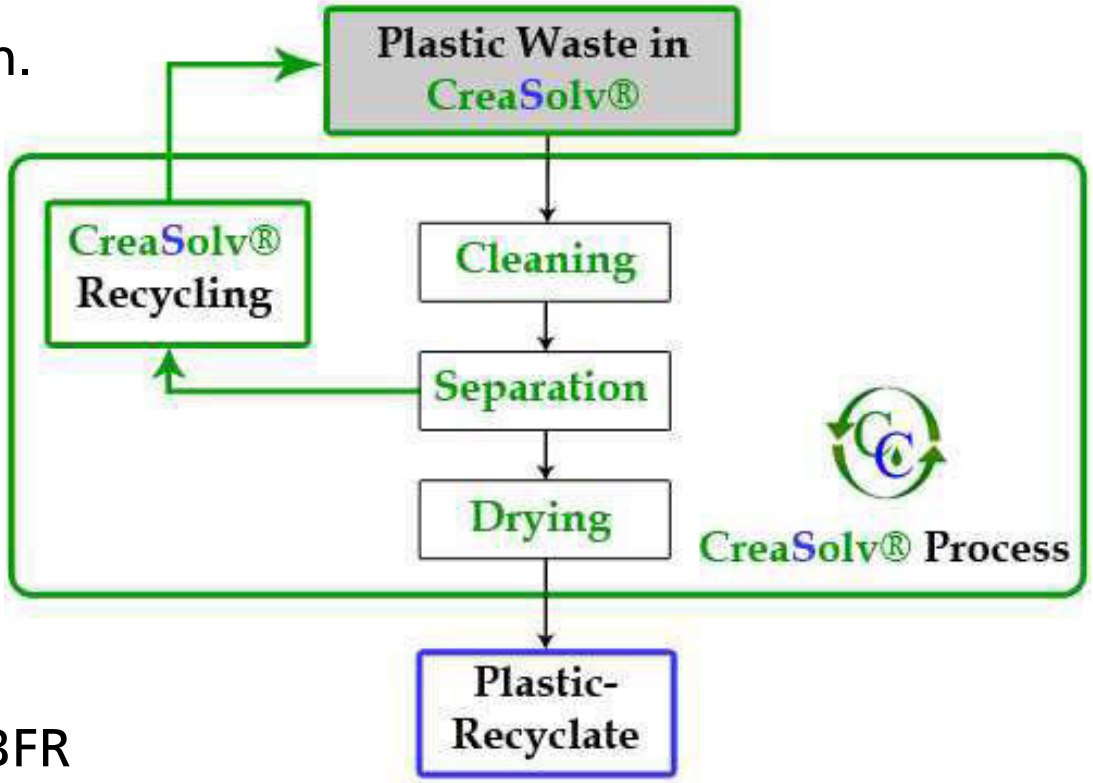


Recycling option – CreaSolv®

CreaSolv® process enables the separation of BFR from BFR plastics by a solvent-based recycling approach.

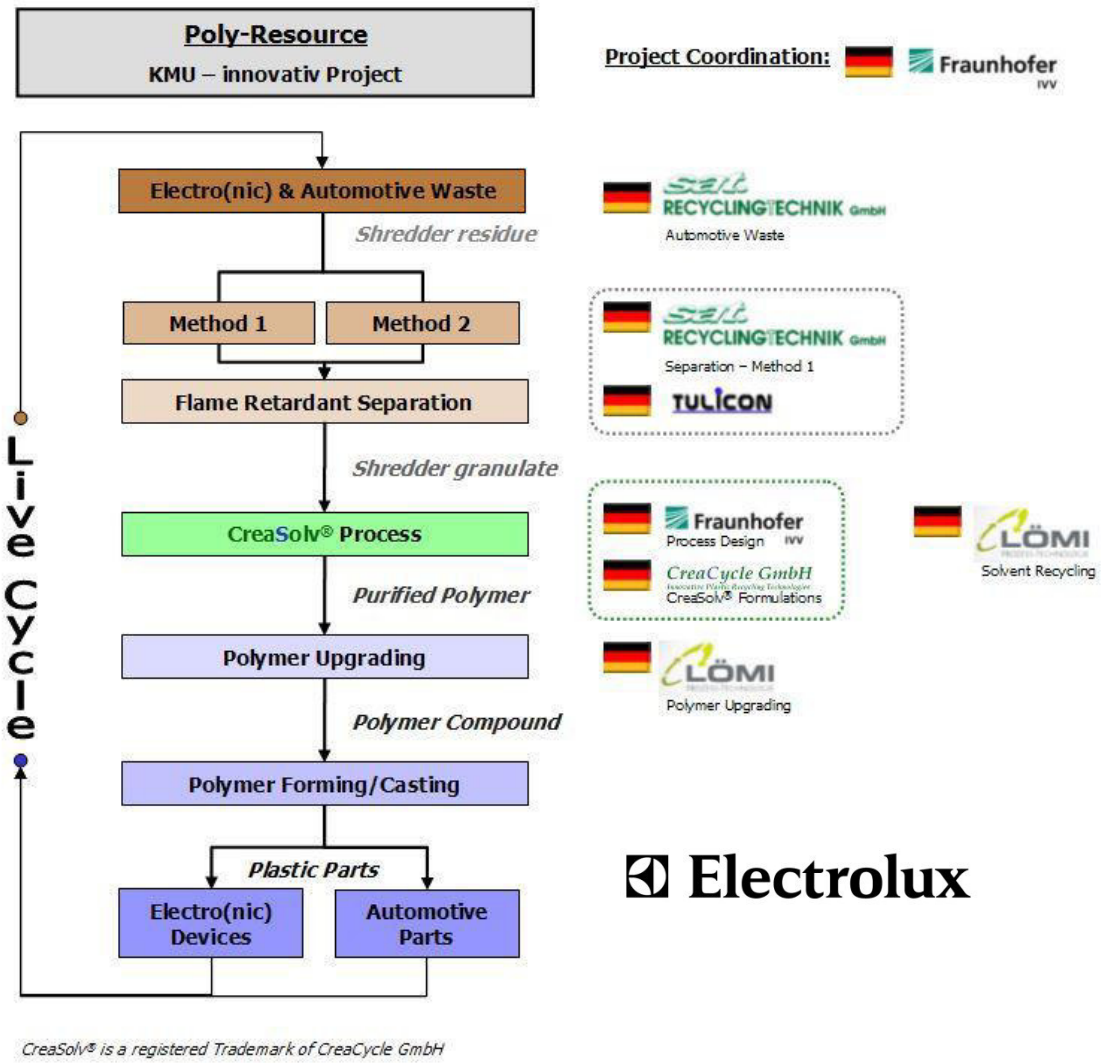
BFR (and PBDD/F) are discharged as a BFR rich residue and may be incinerated. Bromine may be scrubbed from the off-gas and re-used in safe BFR.

Enables the recovery of the maximum amount of polymers (BFR and non-BFR polymers).



CreaSolv® is a registered trademark of Creacycle, Gmbh, Grevenbroich, Germany

Current research – Poly-Ressource



CreaSolv® is a registered Trademark of CreaCycle GmbH

General project targets:

Increasing the **rentability** of the CreaSolv® process by

- Optimising the **process yield**
- Changing batch process steps into **continuous** ones
- Technical **upgrade** of recycled polymers

Test of recyclates with **OEMs**

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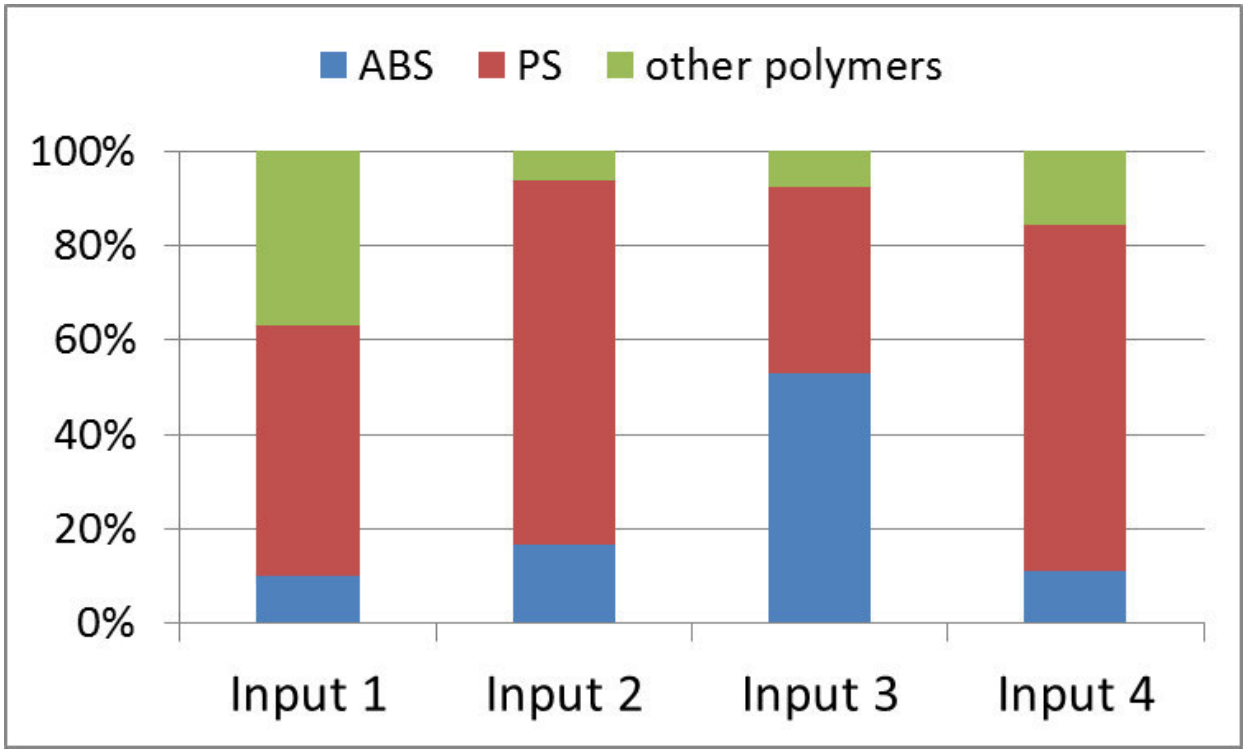
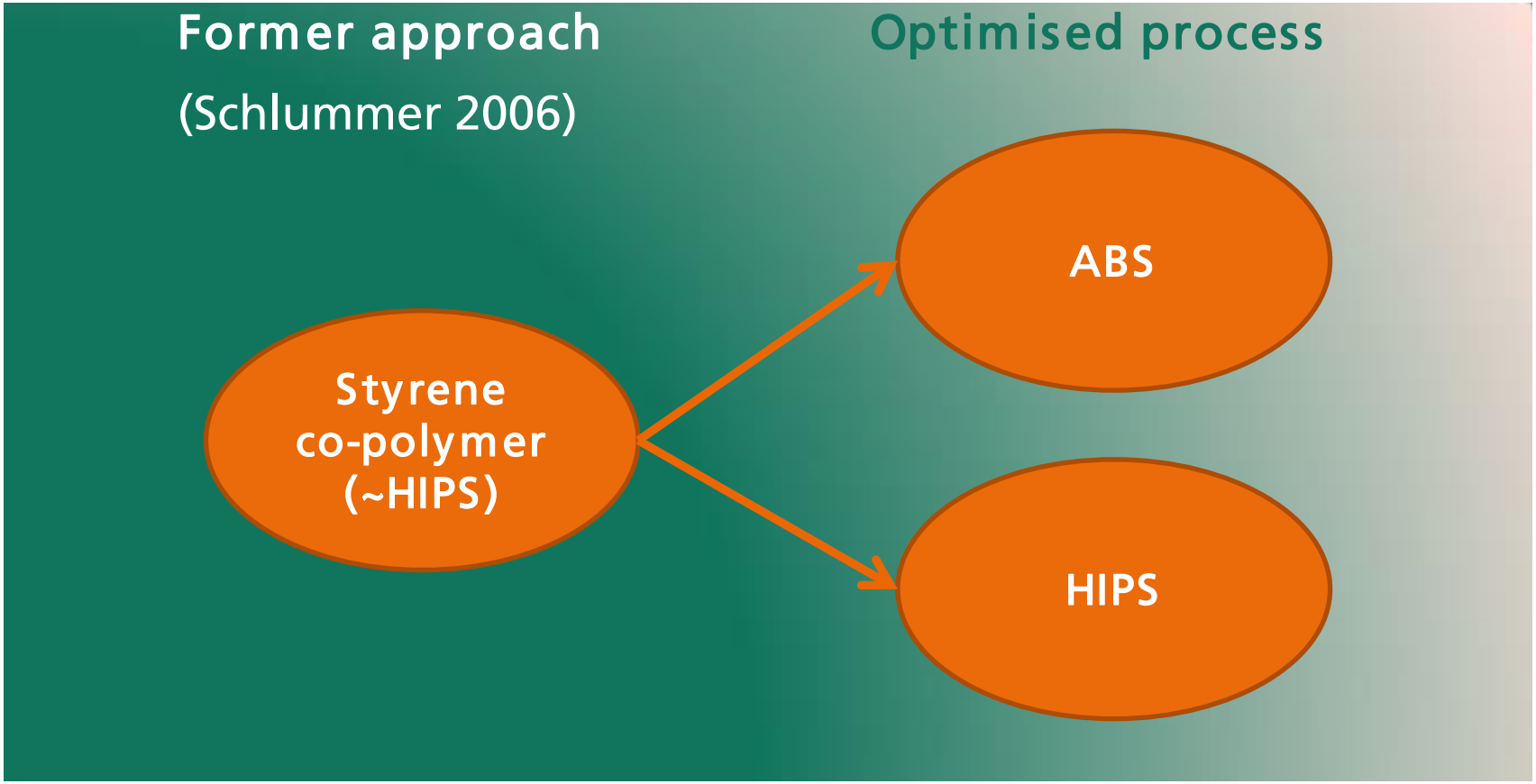
Results – Optimising the yield by pre-treatment

- Density based pre-treatment producedures obtain fractions rich in ABS and PS (60 to 95%)

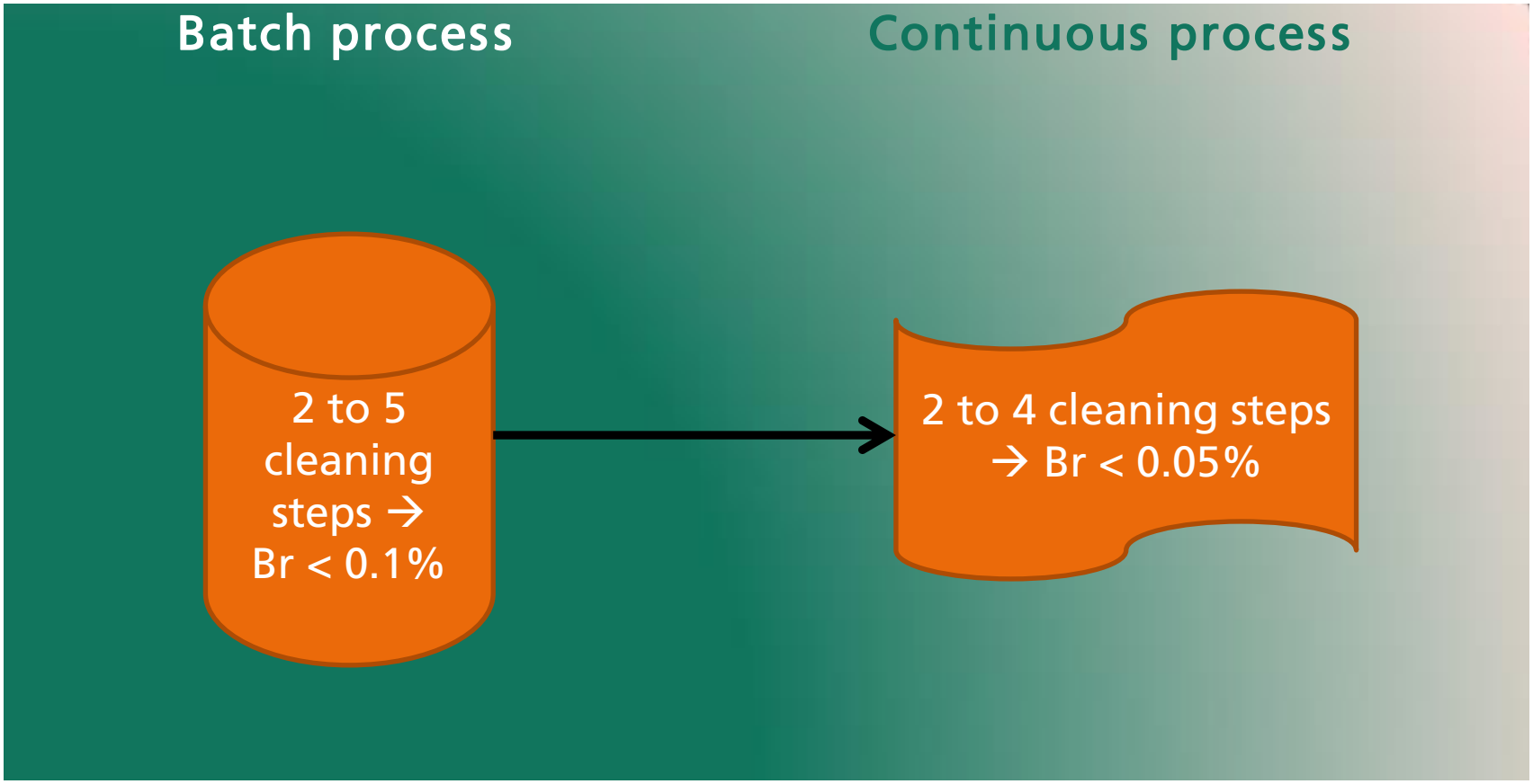


Results – Optimising the yield by stepwise extraction



- Purity and economic value of recycled polymers increase.

Results – Continuous cleaning



- Degree and rate of bromine reduction has slightly improved.
- Volumes of required aggregates and solvents decreased.

Results – Mechanical properties of recycled polymers

- Excerpt from mechanical testing results, performed by Electrolux

		HIPS coarse filtration	HIPS fine filtration
Flexural Modulus (1,3mm/min)	MPa	2109 ± 22	2331 ± 40
Tensile Yield Stress (50mm/min)	MPa	27.1 ± 0.3	30.7 ± 0.7
Strain at Yield (50mm/min)	%	1.7 ± 0.1	1. 7 ± 0.1
Strain at Break (50mm/min)	%	27.3 ± 5.1	13.8 ± 3.8
Impact resistance Izod A	kJ/m2	5.8 ± 0.4	8.1 ± 0.8

Technical Conclusion

CreaSolv® process

a) separates pure polymer types from diverse WEEE plastic mixtures

b) removes foreign materials and contaminants (RoHS compliance!)

c) produces recycled polymers with good physical properties.

→ Technology is ready for Commercialisation !!

→ Alternative to incineration of BFR polymers, which were previously separated by cherry picking techniques.

→ Alternative to global dilution approach (current practice)

The global dilution of BFR plastics

Export of WEEE plastics including BFR

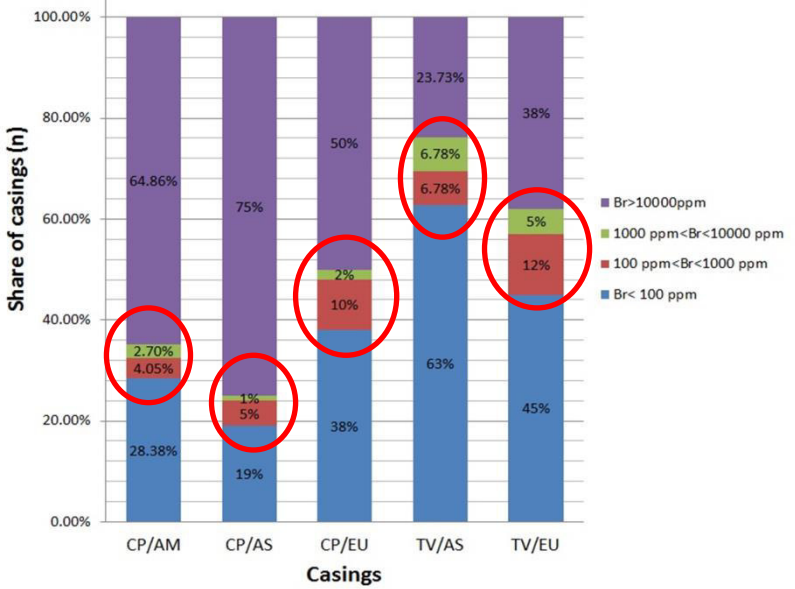
Separate / sort plastics

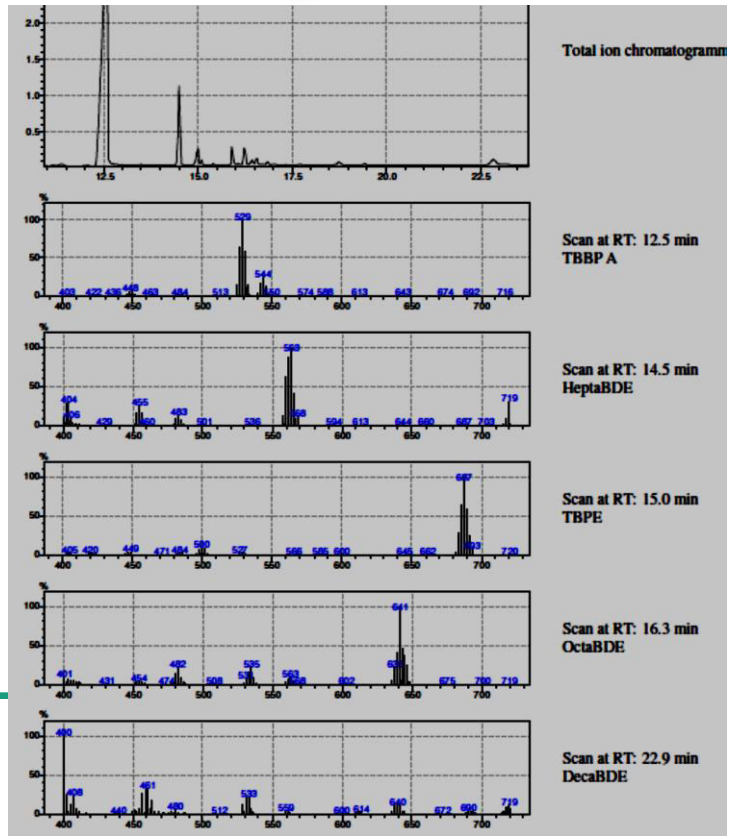
Re-extrude and „dilute“ with virgin polymers

Produce new plastic parts and re-distribute globally (RoHS compliance!!)

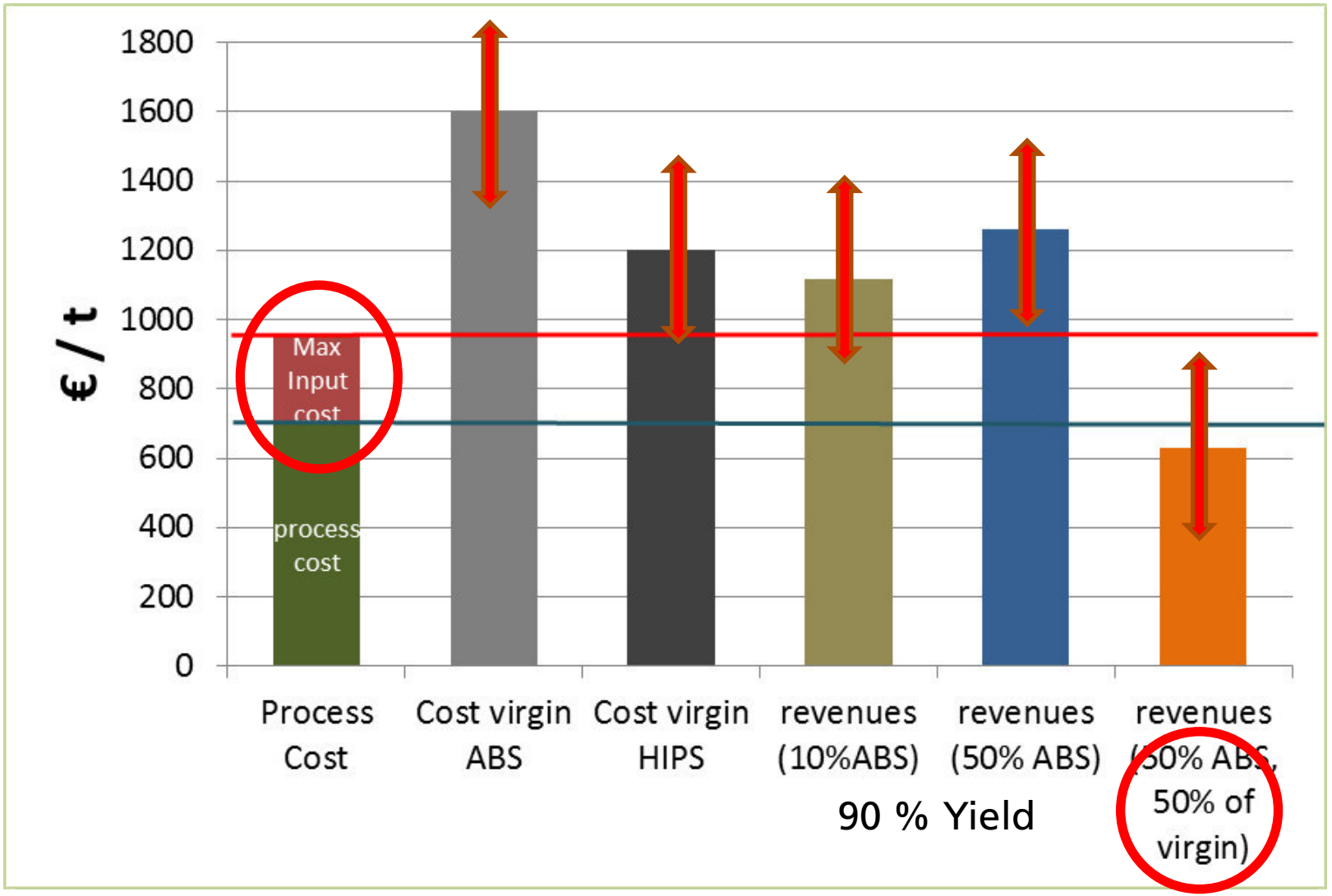
Proof by detection of different BFR types (TBBPA, TBPE & PBDE) in a homogeneous plastic part.

„The global BFR cycle“





Economy



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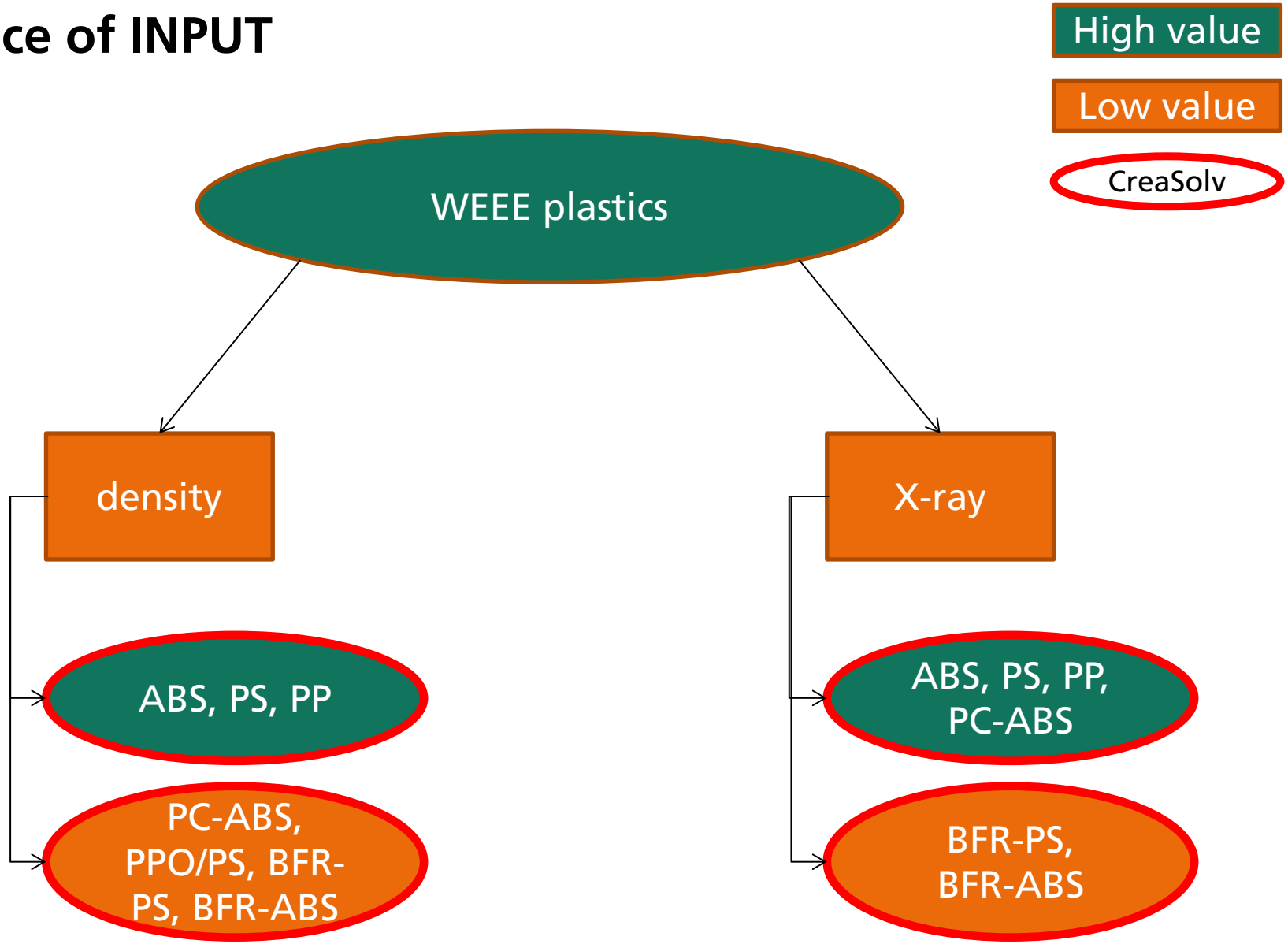
Choice of INPUT



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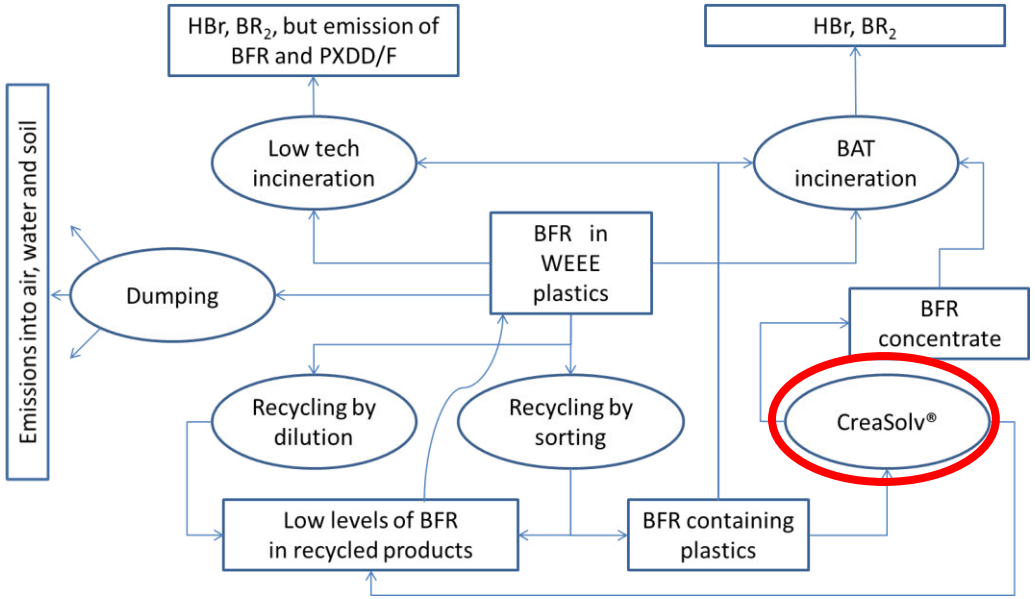
Conclusions - Commericalisation

- Important to apply CreaSolv® to the right INPUT.



CreaSolv®
as a part of a
recycling network.

- Revenues for recycled polymers have to address their real value (>70% of cost of virgin polymers)
- Realisation in co-operation along the value-chain (e.g. collector-recycler-compounder-OEM) in order to balance market swings

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Thank you very much for your attention !!

Literature:

- Guidelines on Best Available Techniques and Best Environmental Practice for the Recycling and Disposal of Articles containing Polybrominated Diphenyl Ethers (PBDEs) under the Stockholm Convention on Persistent Organic Pollutants. UNEP 2012. Draft circulating