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Disassembly based plastics recycling from Waste Electrical and Electronic Equipment (WEEE) for high value applications

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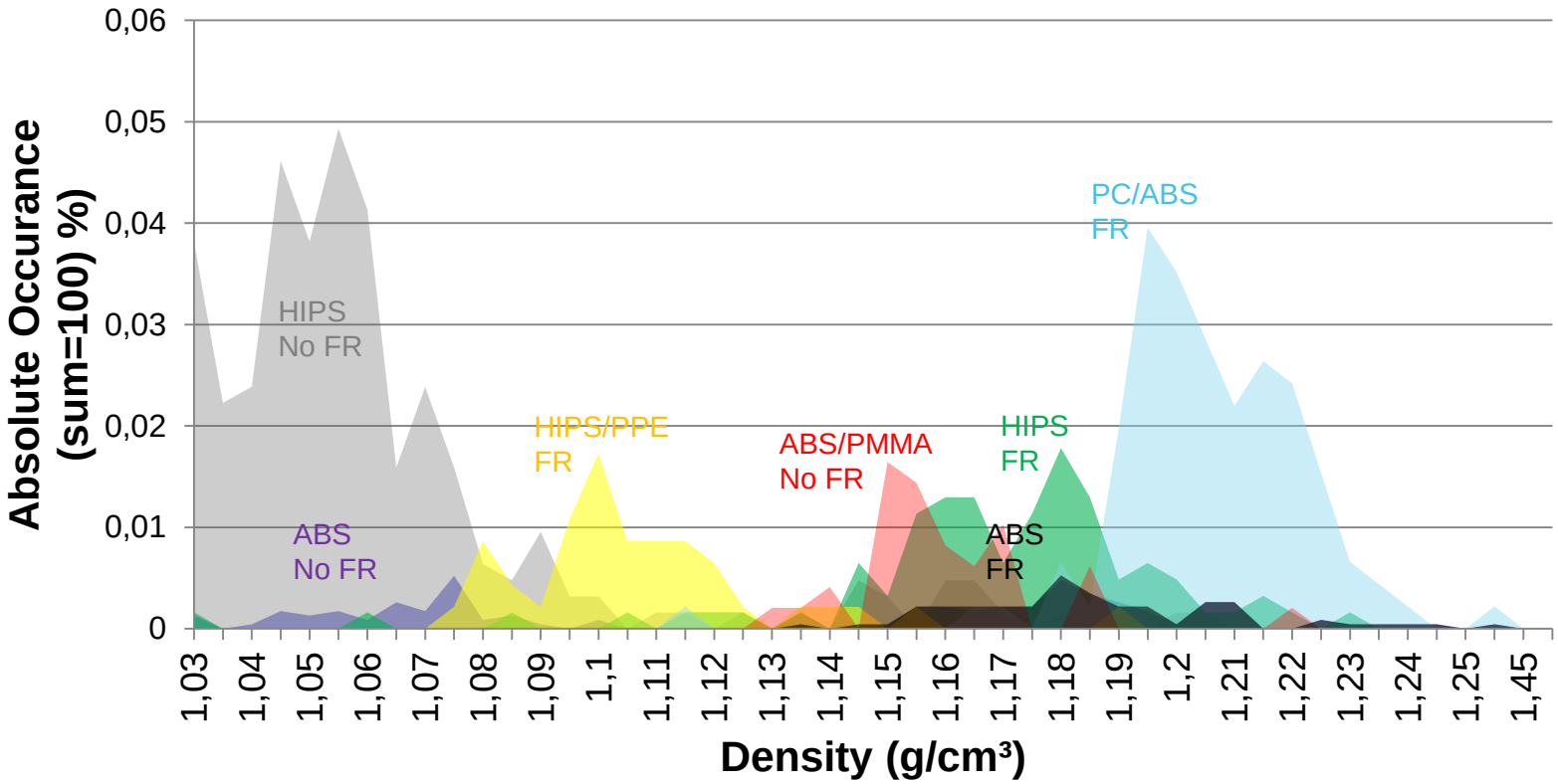
Commercially plastics are separated for recovery after size reduction

Density separation of plastics



- Overlapping physical properties such as density result in a low purity and quality of the separated plastics

J. R. Peeters, P. Vanegas, L. Tange, J. Van Houwelingen, and J. R. Duflou, "Closed loop recycling of plastics containing flame retardants," Resources Conservation & Recycling, vol. 84, pp. 36-43, 2013.

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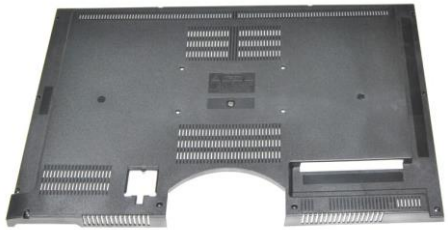
Sorting of plastic components before size reduction



TV Housing

Printed Wiring Boards

- Pre-Sorting to product categories (sometimes required for depollution)
- Product dismantling for purer recovery

Sorting of plastic components before size reduction

Spectroscopic Measurement

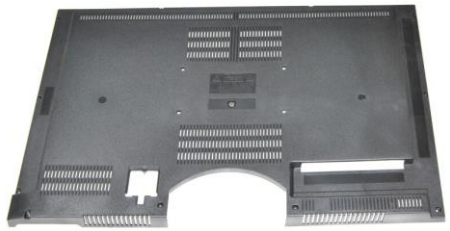
TV Housing

Benefits:

- Targeting of high-quality plastics applied in specific components
- Sorting of up to 3 kg per analysis
- Possible to apply contact measurements
- Value of additives can be recovered (e.g. flame retardants)
- Enables close-loop systems (“back cover to back cover”)

Case study: Disassembly based recycling of LCD TV back covers

- 1,7 million metric tonne of electronic displays were discarded in the EU in 2014
- About 30 wt% of plastics = 510,000 metric tonne plastics annually
- Back covers of the LCD TVs are largest components (45 wt%) = 229,500 metric tonne annually
- Depollution step for mercury removal requires dedicated treatment = separate collection
- Dismantling of recovery of Printed Wiring Boards (PWB) and cables to recover precious metals and copper is already done today



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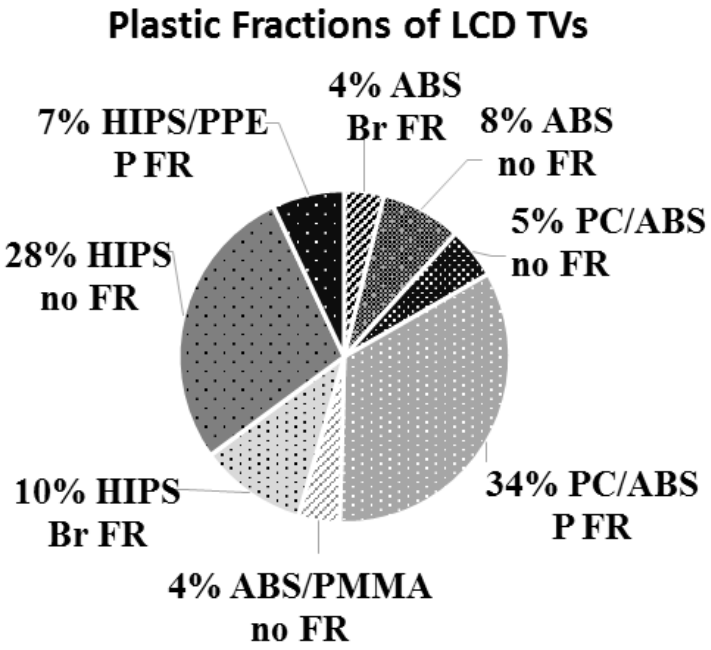
Case study: Plastics in LCD TV back covers



Results of the analysis of 2500 back covers from LCD TVs at a Belgian recycling plant in 2015

ABS – Acrylonitrile Butadiene Styrene
HIPS – High Impact PolyStyrene
PC – PolyCarbonate
PMMA – PolyMethylMethAcrylate
PPE – PolyPhenylene
P – Phosphourus
BR – Bromine
FR – Flame Retardant

A complex mixture in the back covers of LCD TVs of different

- Plastic types
- Colours (mostly black and grey shades)
- Flame retardants (Bromine and Phosphor based)

F. Wagner, J. R. Peeters, J. De Keyzer, J. R. Duflou and W. Dewulf, “Evaluation of the quality of post-consumer recyclates from distinct recycling strategies," *Proceedings of the Polymers & Moulds Innovations 2016 Conference in Ghent,* pp. 307-312, 2016.

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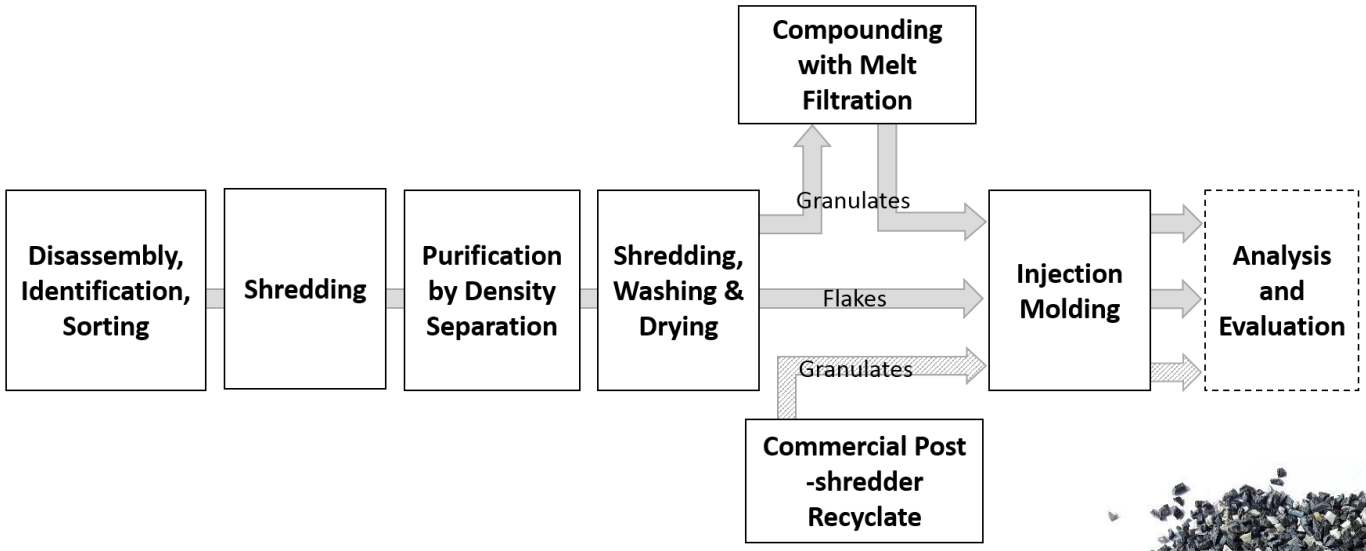
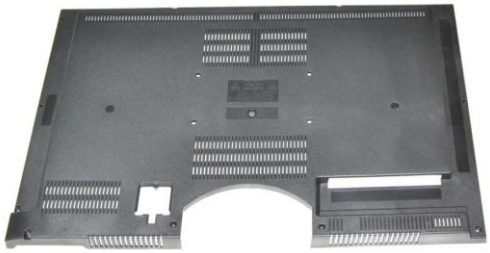
Disassembly based recycling process





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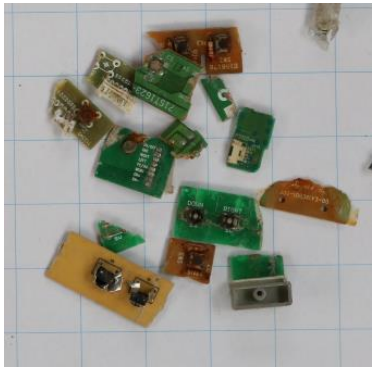
Purification by two-step density separation

	Fractions	Density g/cm³	PC/ABS with P Average %	min	max
	Float		**6,3**	6,7	6,0
1	Plastics	< 1,16	**6,2**	6,7	6,0
	Films and Labels		**0,0**	0,0	0,0
	Others (Foams, rubbers, ...)		**0,1**	0,1	0,0
2	**Pure**		**90,9**	91,3	90,7
	Sink		**2,9**	3,2	2,6
3	Metals and plastic with metals	> 2,26	**0,7**	1,1	0,5
	Plastics		**2,0**	2,4	1,8
	Circuit Boards		**0,0**	0,1	0,0
	Others (Labels, Rubbers, Glass, ...)		**0,1**	0,1	0,0

Printed Wiring Boards



Metals and
metal insertions in plastics

Mayor impurities expected due to the product design of LCD TV back covers could be removed by density separation

Purification by density separation

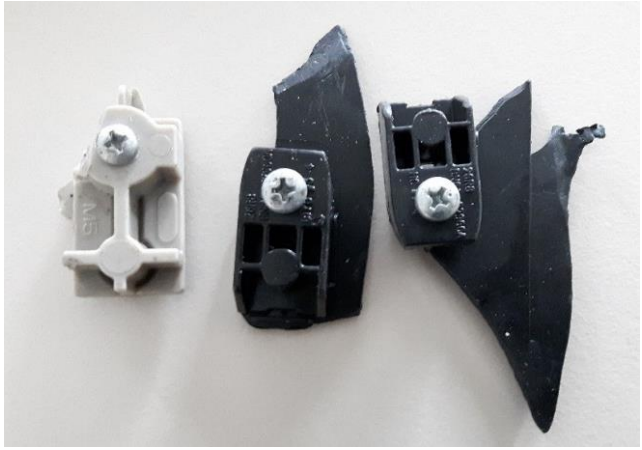
Found in the purified fraction:

- Labels could not be removed and were found in the purified fractions

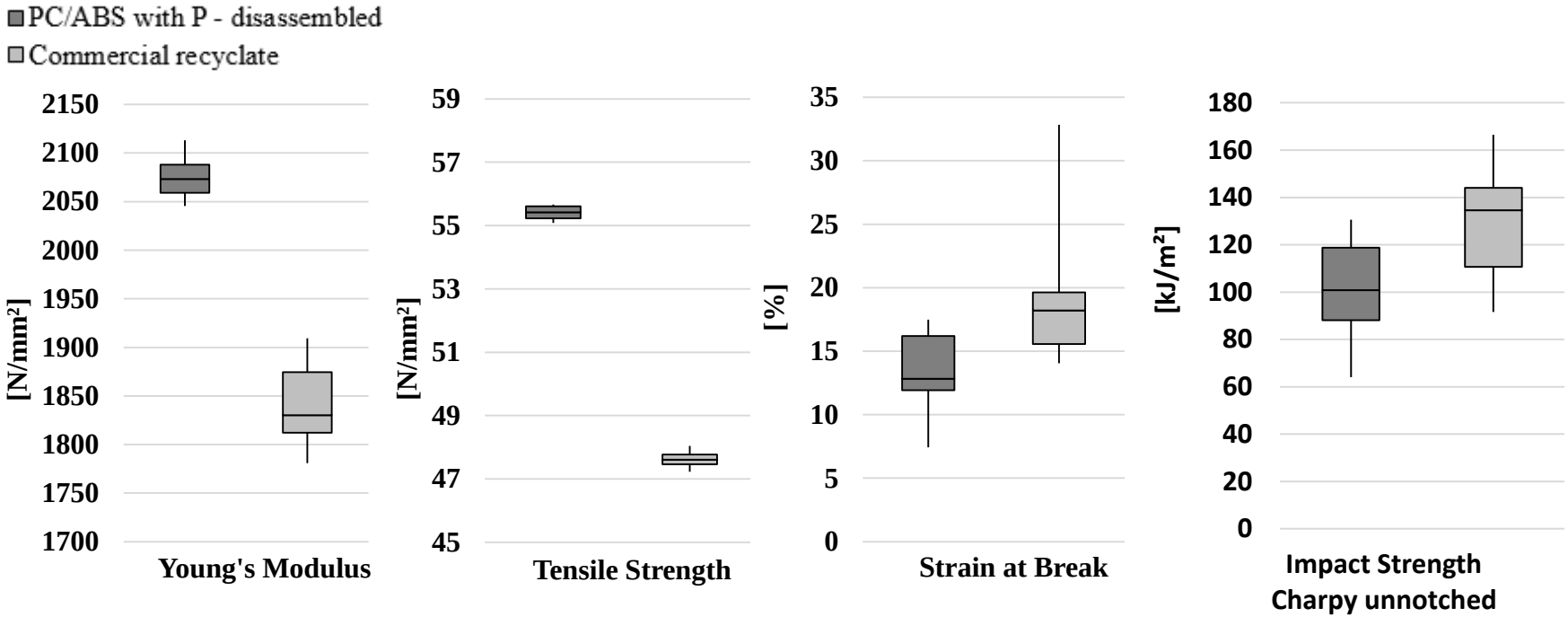
  ⇒ Melt filtration

- Components with metal screw and cavity combinations could be found

  ⇒ Shredding to smaller pieces



Mechanical testing of PC/ABS with P FR



- Commercially recycled PC/ABS was treated in a compounding step, where mechanical properties (e.g. impact strength) can be improved
- Higher Young's Modulus and tensile strength and comparable strain at break and impact strength values could be achieved

Impurities in fracture surfaces

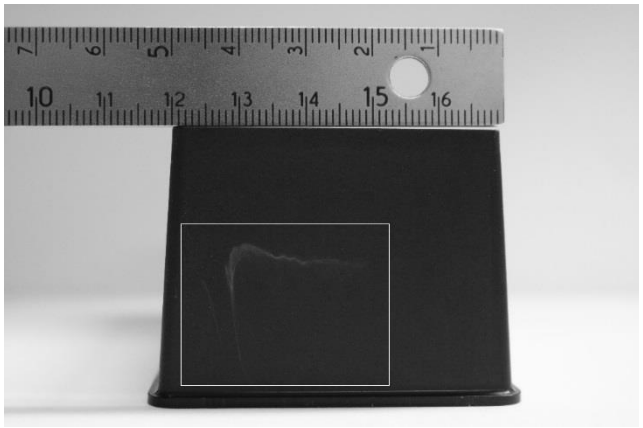
Labels and plastic pieces in the fracture surfaces of tested tensile bars

Pictures taken after tests with ABS

Injection moulding of thin-walled boxes

Recyclate can be applied directly into thin-walled products with injection moulding without a melt filtration step in a compounding process

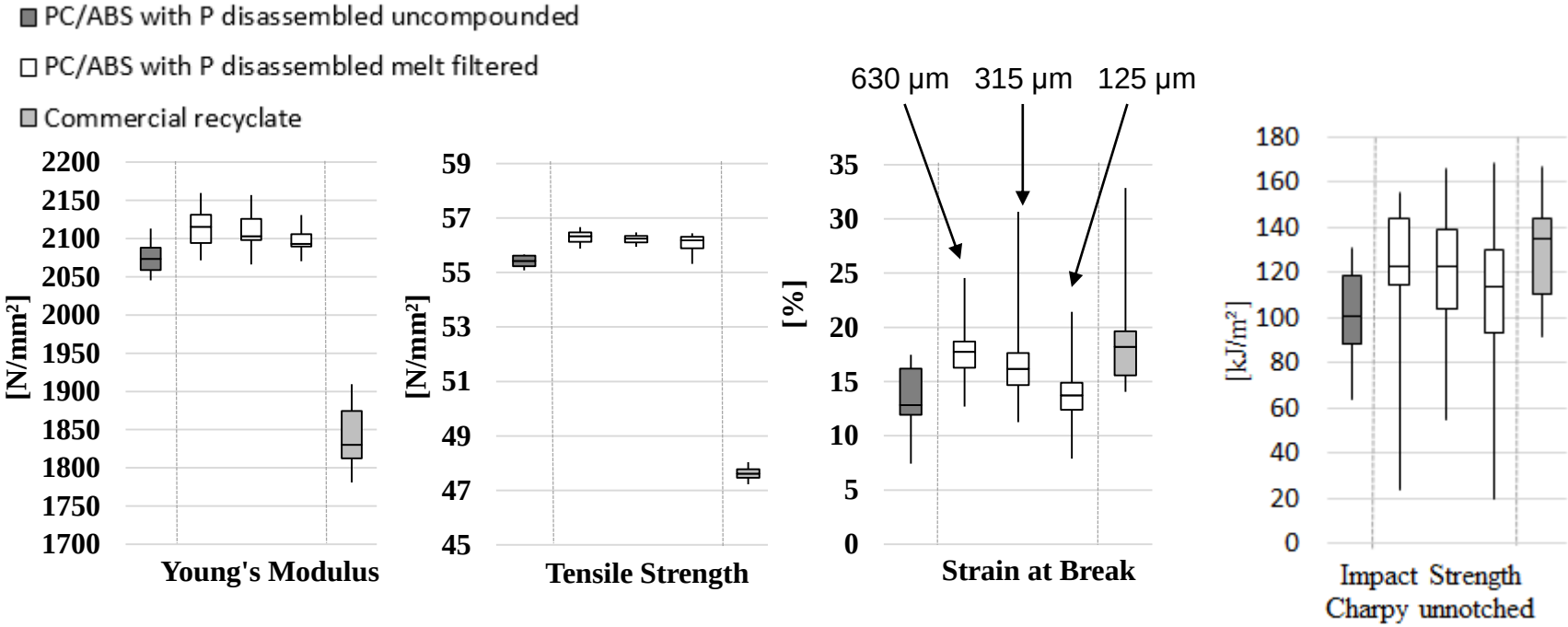
Remaining label pieces and splay marks were observed in the surface of some boxes



Pictures taken after tests with ABS

Compounding with melt filtration

Compounding with melt filtration



- Slight improvement of most mechanical values
- Stronger deviation in strain at break and impact strength values
- No significant improvement of the mechanical values with finer mesh sizes
- Large label impurities could be removed

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Aesthetical evaluation

- Good aesthetical properties with standard processing conditions
- High-gloss could be achieved for PC/ABS with Gloss Units of around 98 with a 20° angle
- No differences in gloss could be observed for the different mesh sizes

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Dismantling based recycling of plastics

- Good mechanical properties can be achieved
- Application thin-walled, injection moulded products is possible without melt filtration
- Remaining impurities and splay limit the application to non-structural components with low aesthetical requirements

- Compounding with melt filtration showed slight improvement of the mechanical values
- Good aesthetical properties could be achieved

- Dismantling based recycling of plastics shows potential to produce recyclates with a much higher quality than achievable by post-shredder separation

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Quality and Value

- Potential to produce high quality recyclates for high-end aplications replacing virgin plastic
- Application in structural and aesthetical components can open new markets for recycled plastics
- Recovery of flame retardant plastics
- Good mechanical properties could buffer quality flaws of commercial processes
- Support a closed loop plastic recycling system

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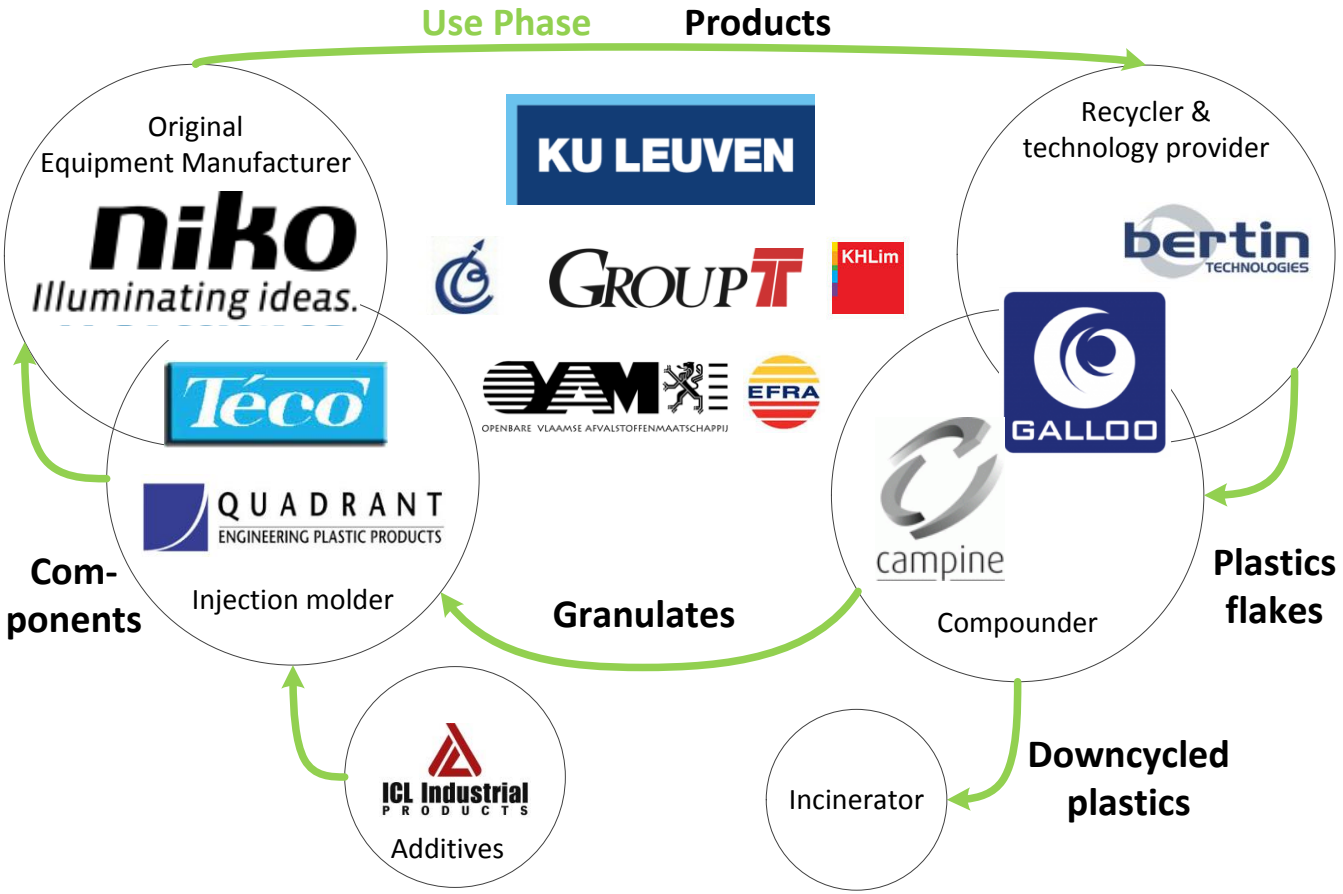
Next Level Plastic Recycling Project



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