# Monitoring of recycled plastics
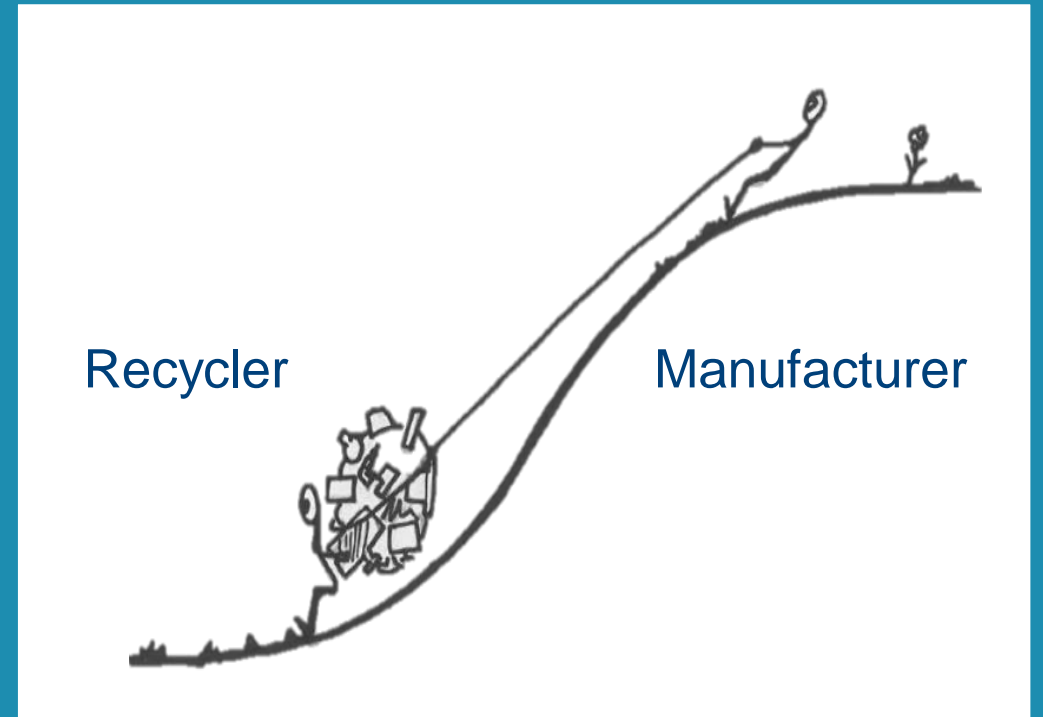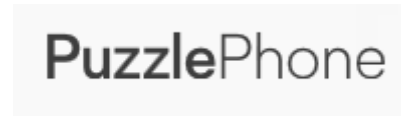
Recycler

Manufacturer

Prof. Dr. Ing. MSc. Jef Peeters

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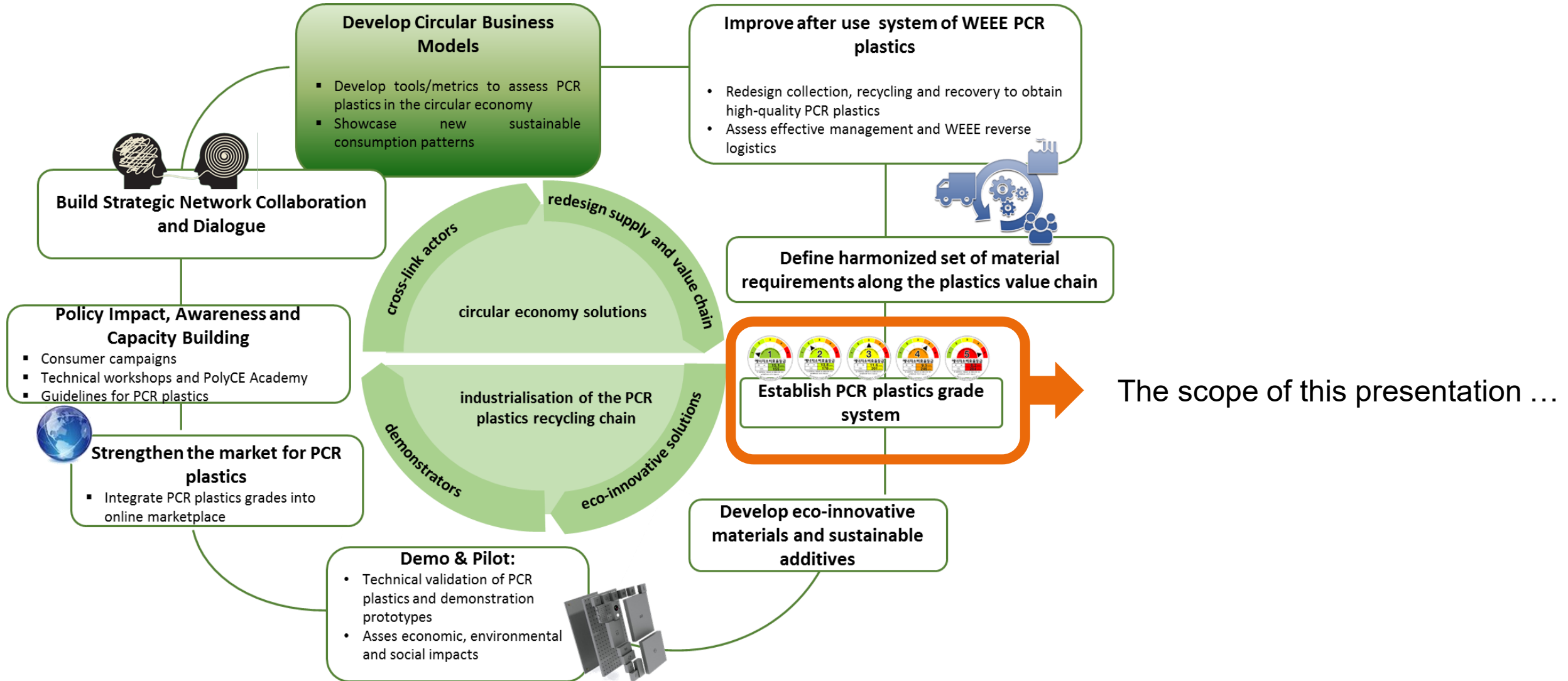# The H2020 PolyCe Project partners

20 key players with **expertise covering the full lifecycle of high-tech polymers**

# The PolyCe Objectives

**Develop Circular Business Models**

- Develop tools/metrics to assess PCR plastics in the circular economy
- Showcase new sustainable consumption patterns

**Improve after use system of WEEE PCR plastics**

- Redesign collection, recycling and recovery to obtain high-quality PCR plastics
- Assess effective management and WEEE reverse logistics

**Build Strategic Network Collaboration and Dialogue**

**Policy Impact, Awareness and Capacity Building**

- Consumer campaigns
- Technical workshops and PolyCE Academy
- Guidelines for PCR plastics

**Strengthen the market for PCR plastics**

- Integrate PCR plastics grades into online marketplace

**Demo & Pilot:**

- Technical validation of PCR plastics and demonstration prototypes
- Asses economic, environmental and social impacts

**Develop eco-innovative materials and sustainable additives**

**Define harmonized set of material requirements along the plastics value chain**

**Establish PCR plastics grade system**

The scope of this presentation …

*Circle diagram labels:* cross-link actors · redesign supply and value chain · circular economy solutions · industrialisation of the PCR plastics recycling chain · eco-innovative solutions · demonstrators

# What is the grade of plastics from fridges?

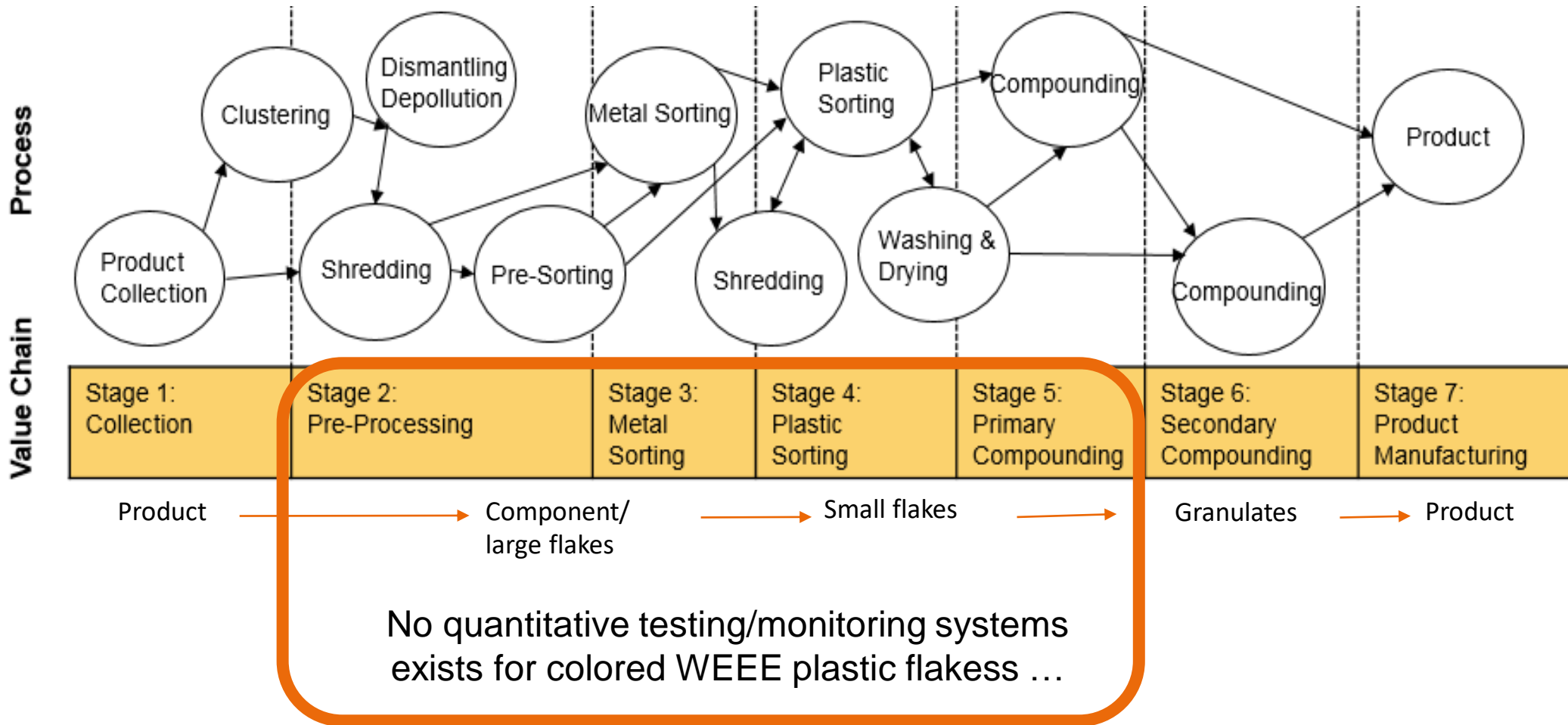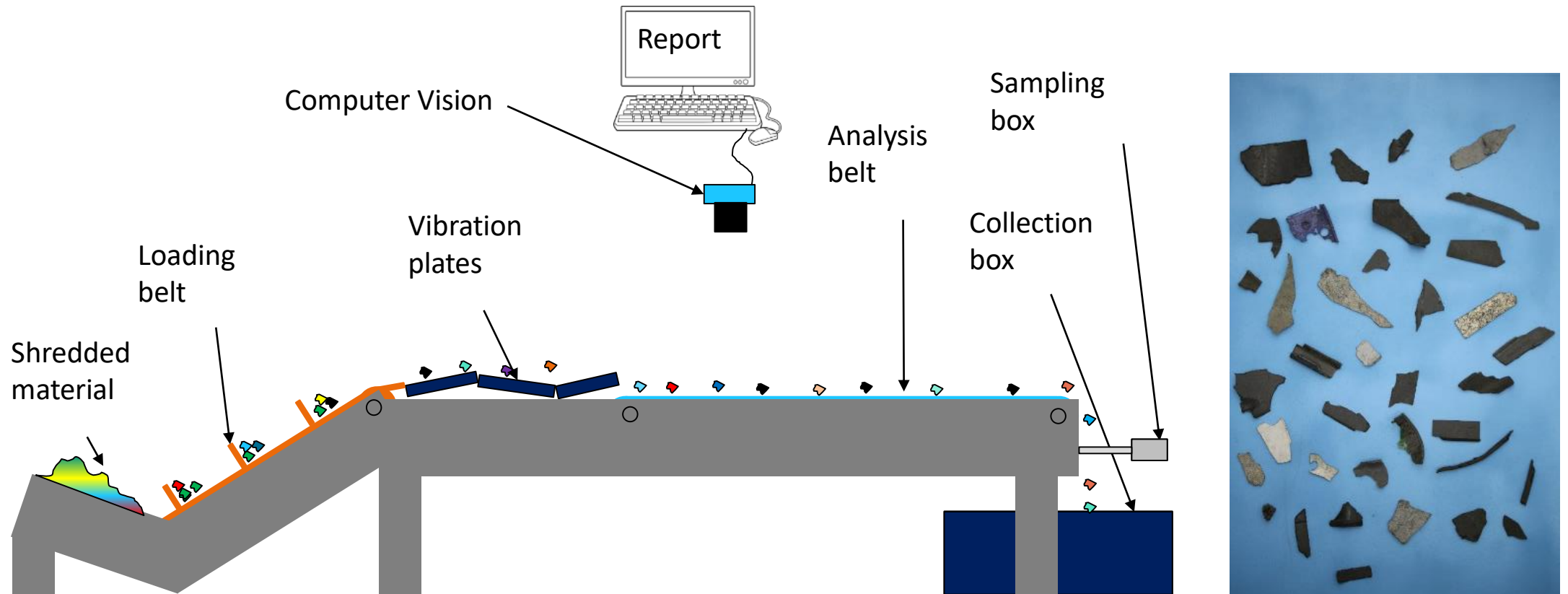# What is the plastic grade ?



V.S.

V.S.
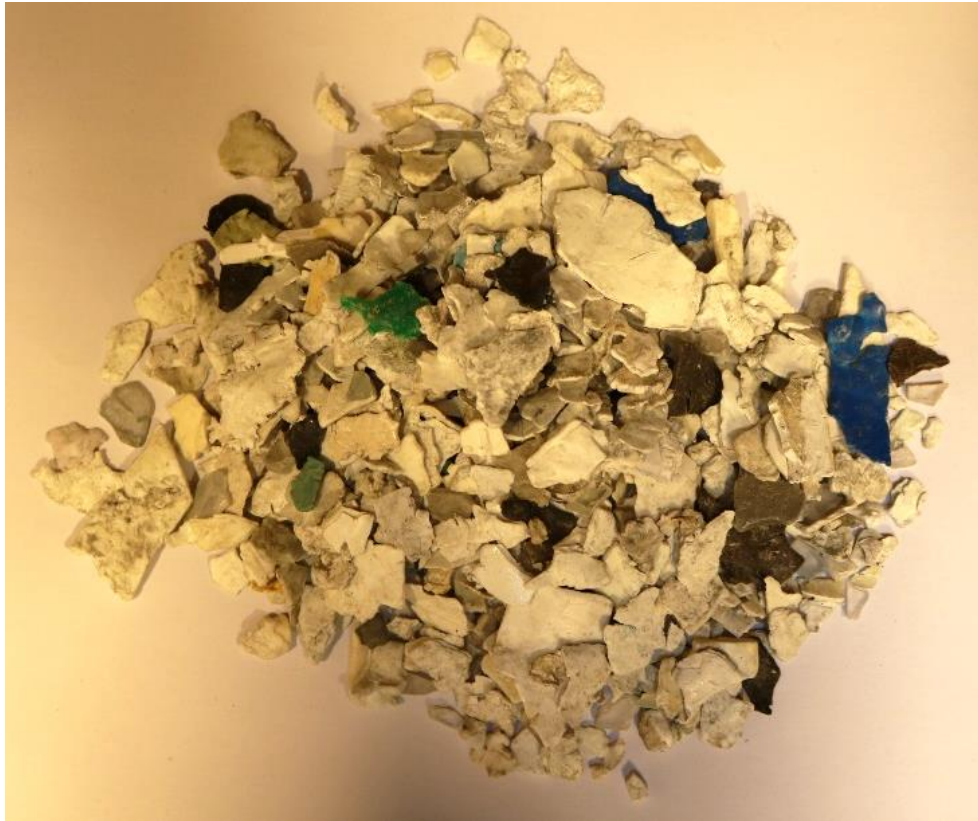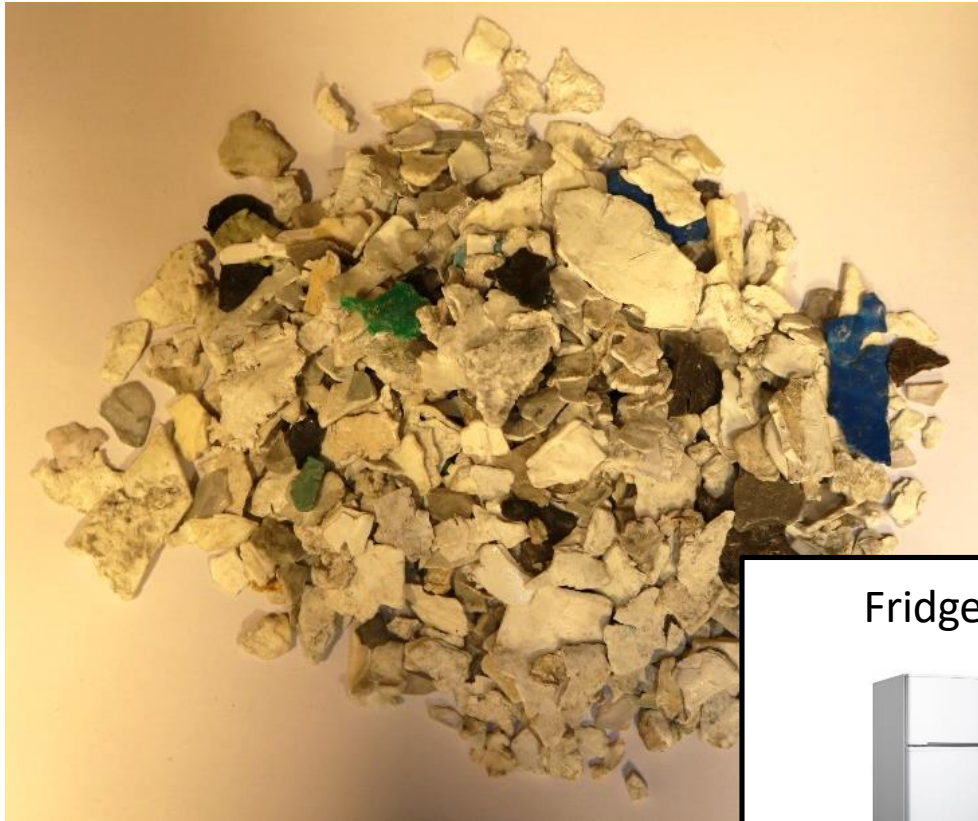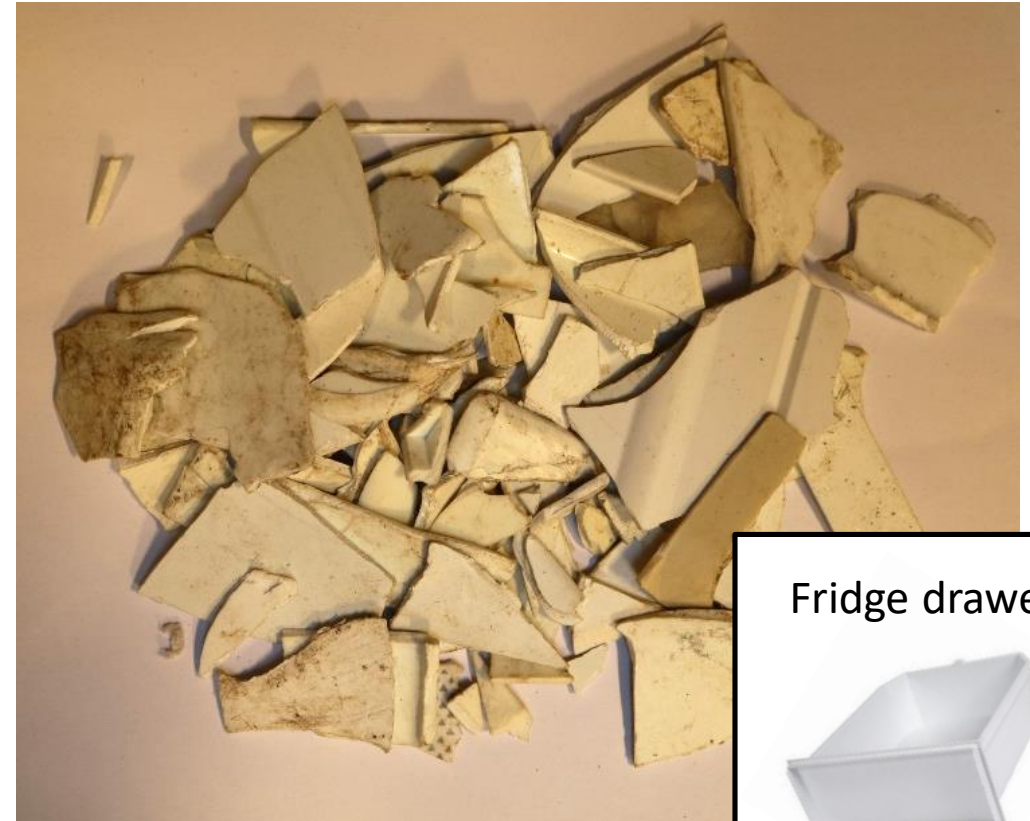
Fridges

Fridge drawers

# Quality management for the plastic value chain …



**Process**

Clustering — Dismantling Depollution — Metal Sorting — Plastic Sorting — Compounding — Product

Product Collection — Shredding — Pre-Sorting — Shredding — Washing & Drying — Compounding

**Value Chain**

| Stage 1: Collection | Stage 2: Pre-Processing | Stage 3: Metal Sorting | Stage 4: Plastic Sorting | Stage 5: Primary Compounding | Stage 6: Secondary Compounding | Stage 7: Product Manufacturing |

Product → Component/ large flakes → Small flakes → Granulates → Product

No quantitative testing/monitoring systems exists for colored WEEE plastic flakess …

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# Computer vision for plastic flakes analysis

# Computer vision for plastic flakes analysis
### Fridges

# Complexity of the Quality of recycled plastics

Waste Stream/Product          Recycling Process          Final Quality

Composition

Separation Properties

Product Design

Separation

Liberation

Purity

Ageing before recycling

Ageing due to Process

Degradation

# Complexity of the Quality of recycled plastics

Waste Stream/Product          Recycling Process          Final Quality

Composition

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Separation Properties

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Ageing before recycling

Ageing due to Process

Degradation

Quality Management    =    Metadata    +    Testing

# Testing scheme for plastic flakes



**Computer Vision**
- Size Distribution
- Colour
- Contaminations

**Automated FTIR**
- Plastic Composition

**XRF**
- Metals
- Restricted substances

**Mixed Plastic Flakes**

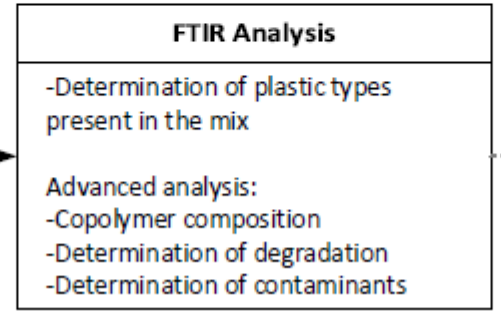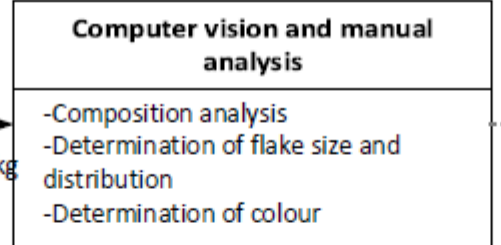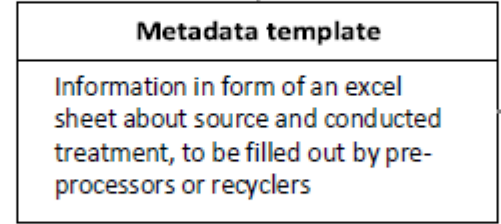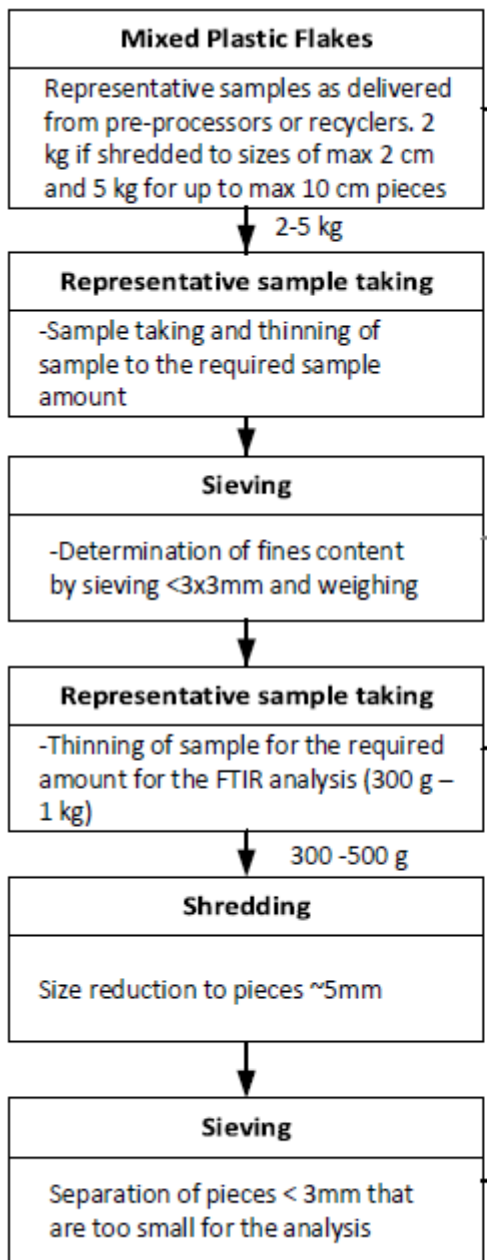Representative samples as delivered from pre-processors or recyclers. 2 kg if shredded to sizes of max 2 cm and 5 kg for up to max 10 cm pieces

2-5 kg

**Representative sample taking**

-Sample taking and thinning of sample to the required sample amount

**Sieving**

-Determination of fines content by sieving <3x3mm and weighing

**Representative sample taking**

-Thinning of sample for the required amount for the FTIR analysis (300 g – 1 kg)

300 -500 g

**Shredding**

Size reduction to pieces ~5mm

**Sieving**

Separation of pieces < 3mm that are too small for the analysis

100 g

**Metadata template**

Information in form of an excel sheet about source and conducted treatment, to be filled out by pre-processors or recyclers

**Computer vision and manual analysis**

-Composition analysis
-Determination of flake size and distribution
-Determination of colour

1,7 – 4,5 kg

**FTIR Analysis**

-Determination of plastic types present in the mix

Advanced analysis:
-Copolymer composition
-Determination of degradation
-Determination of contaminants

**Testing Results**

Metadata
-Source
-Company
-Processing steps
-...

Fines Content (%)

Composition:
-Metals (%)
-Glass (%)
-Foams (%)
-Wood (%)
-Plastics (%)
-...
Flake size (mm)
Flake colour composition (RAL)

Plastic composition:
-ABS (%)
-HIPS (%)
-PC/ABS (%)
-PP (%)
-PVC (%)
Advanced analysis:
-Copolymer composition ABS (%)
-Rubber content HIPS (%)
-Degraded plastics (%)

---

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# Results of composition analysis

| [wt%] | Fridges | Fridges no flotation | Fridge drawers |
|---|---|---|---|
| Plastics | 97.5 | 80.9 | 100.0 |
| *HIPS* | *47.4* | *41.1* | *1.1* |
| *PS* | *16.7* | *20.6* | *89.3* |
| *ABS* | *23.0* | *11.8* | |
| *SAN* | | | *5.1* |
| *PP unfilled* | *2.5* | | |
| *PP CaCO₃* | *2.5* | *1.5* | |
| *PP talc* | | | |
| *PE* | *1.3* | | |
| *PVC* | *0.1* | *3.0* | |
| *PC* | | | *4.5* |
| *PC/ABS* | *3.8* | | |
| *Other Plastics* | | *3.0* | |
| Metals | 0.4 | 9.7 | 0.0 |
| Rubber | 0.1 | 0.0 | 0.0 |
| Glass | 0.1 | 0.6 | 0.0 |
| Wood, Paper | 0.1 | 0.1 | 0.0 |
| Foam | 0.0 | 0.0 | 0.0 |
| Other | 0.0 | 0.1 | 0.0 |
| Fines <3 mm | 1.9 | 8.5 | 0.0 |

Automated FTIR

MCA

# Communication of the results of the testing



**Computer Vision**
- Size Distribution
- Colour
- Contaminations

**Automated FTIR**
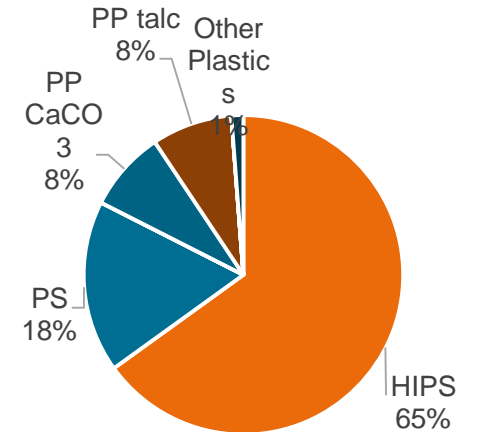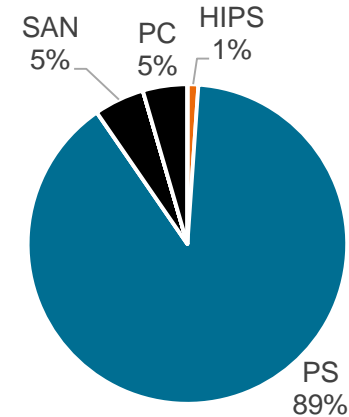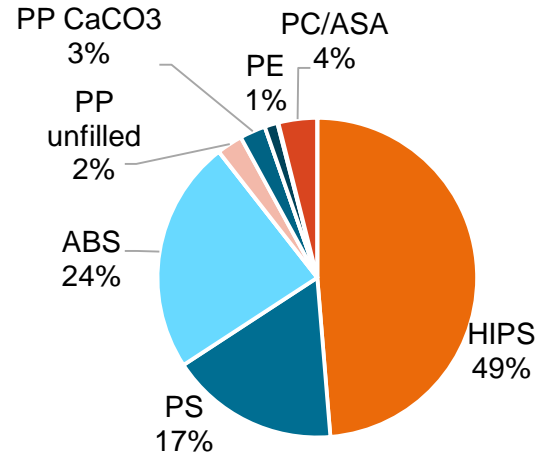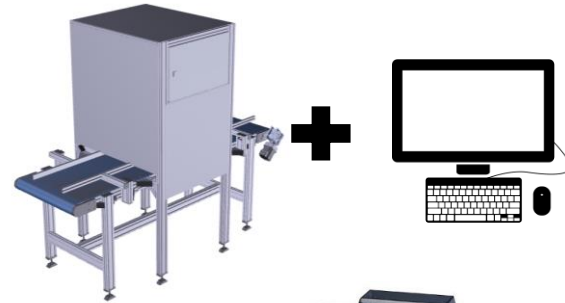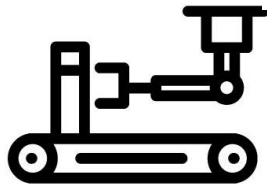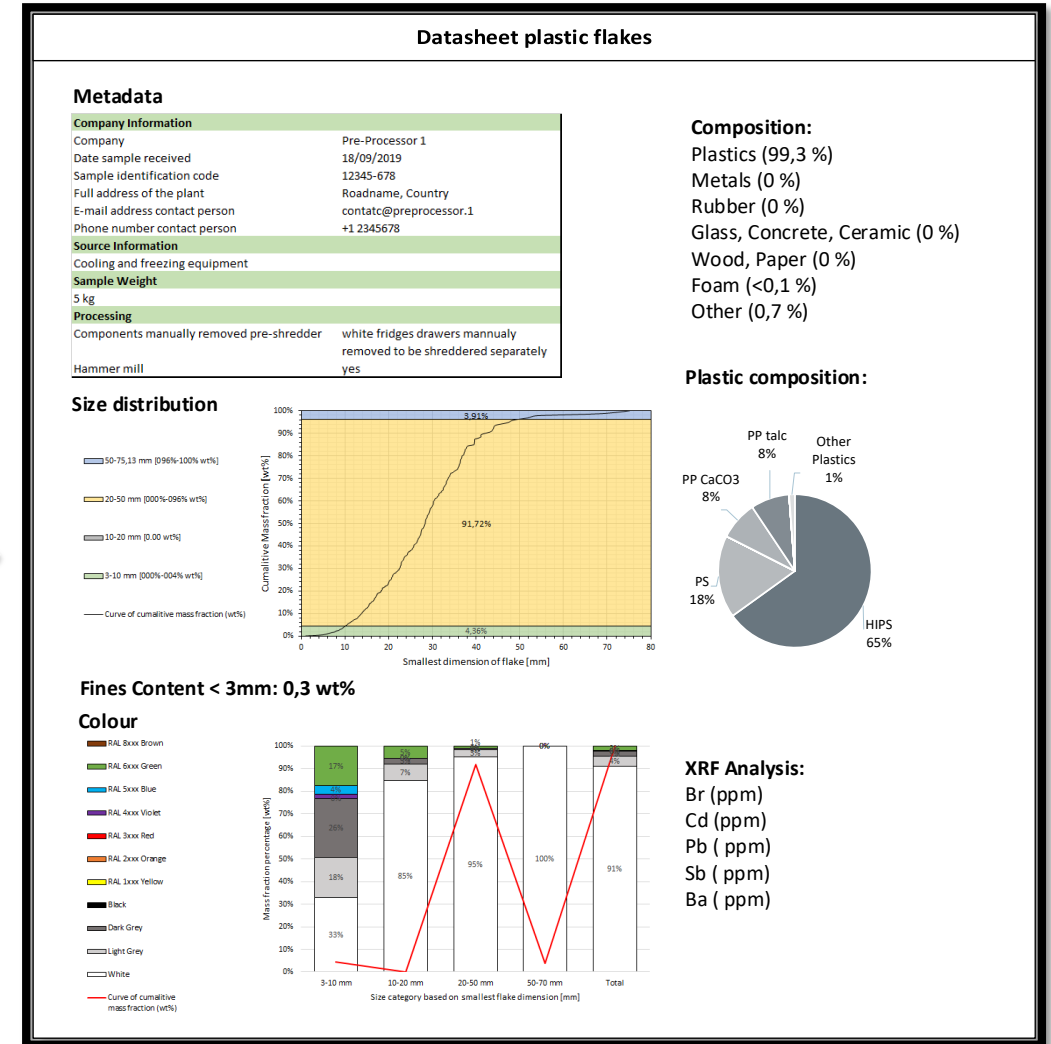- Plastic Composition

**XRF**
- Metals
- Restricted substances

**Automated sample preparation**

## Datasheet plastic flakes

### Metadata

| Company Information | |
|---|---|
| Company | Pre-Processor 1 |
| Date sample received | 18/09/2019 |
| Sample identification code | 12345-678 |
| Full address of the plant | Roadname, Country |
| E-mail address contact person | contatc@preprocessor.1 |
| Phone number contact person | +1 2345678 |
| **Source Information** | |
| Cooling and freezing equipment | |
| **Sample Weight** | |
| 5 kg | |
| **Processing** | |
| Components manually removed pre-shredder | white fridges drawers mannualy removed to be shreddered separately |
| Hammer mill | yes |

**Composition:**
- Plastics (99,3 %)
- Metals (0 %)
- Rubber (0 %)
- Glass, Concrete, Ceramic (0 %)
- Wood, Paper (0 %)
- Foam (<0,1 %)
- Other (0,7 %)

### Size distribution

Legend:
- 50-75,13 mm [096%-100% wt%]
- 20-50 mm [000%-096% wt%]
- 10-20 mm [0.00 wt%]
- 3-10 mm [000%-004% wt%]
- Curve of cumalitive mass fraction (wt%)

**Plastic composition:**

Pie chart: PP talc 8%, Other Plastics 1%, PP CaCO3 8%, PS 18%, HIPS 65%

**Fines Content < 3mm: 0,3 wt%**

### Colour

Legend:
- RAL 8xxx Brown
- RAL 6xxx Green
- RAL 5xxx Blue
- RAL 4xxx Violet
- RAL 3xxx Red
- RAL 2xxx Orange
- RAL 1xxx Yellow
- Black
- Dark Grey
- Light Grey
- White
- Curve of cumalitive mass fraction (wt%)

**XRF Analysis:**
- Br (ppm)
- Cd (ppm)
- Pb ( ppm)
- Sb ( ppm)
- Ba ( ppm)

# To conclude

Grading scale
1 2 3 4 5 6 7 8 9 10

-Impurities

-Additives

-Contaminants

-Irreversible chemical changes

| Influences on Quality | Probability of presence | | Probability of non-detection | | | | | | Severity on quality | | Risk Priority | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TV Housings | Washing Machines | FTIR | XRF | MCA(CV) | Density | MFI | GC, MS or ICP with MS | Mechanical Properties | Legal Compliance | No testing | FTIR+XRF+MCA (CV) | All techniques |
| Metals | 10 | 10 | 9 | 2 | 2 | 6 | 10 | 10 | 9 | 1 | 900 | 180 | 180 |
| Rubber | 7 | 8 | 2 | 10 | 2 | 6 | 10 | 6 | 9 | 1 | 720 | 144 | 144 |
| Foam | 7 | 7 | 2 | 10 | 2 | 7 | 10 | 6 | 8 | 2 | 800 | 160 | 160 |
| Glassfibre | 2 | 10 | 9 | 10 | 10 | 6 | 10 | 8 | 8 | 1 | 800 | 720 | 240 |
| Phosphor based FRs | 10 | 3 | 7 | 8 | 10 | 6 | 10 | 2 | 6 | 1 | 600 | 420 | 120 |
| Brominated FRs | 10 | 4 | 7 | 3 | 10 | 7 | 10 | 2 | 7 | 10 | 1000 | 300 | 200 |
| Chain scission | 8 | 8 | 10 | 10 | 10 | 10 | 6 | 10 | 8 | 2 | 720 | 720 | 432 |

⇒ A method for the quality assessment of mixed plastic flakes is proposed between pre-processors and recyclers, which is often subject to trade.

⇒ The material composition and the size and colour distribution can be analysed.

⇒ FMEA allows to determine quality risks for recycled plastics.

⇒ The importance of source information to control restricted substances is highlighted.
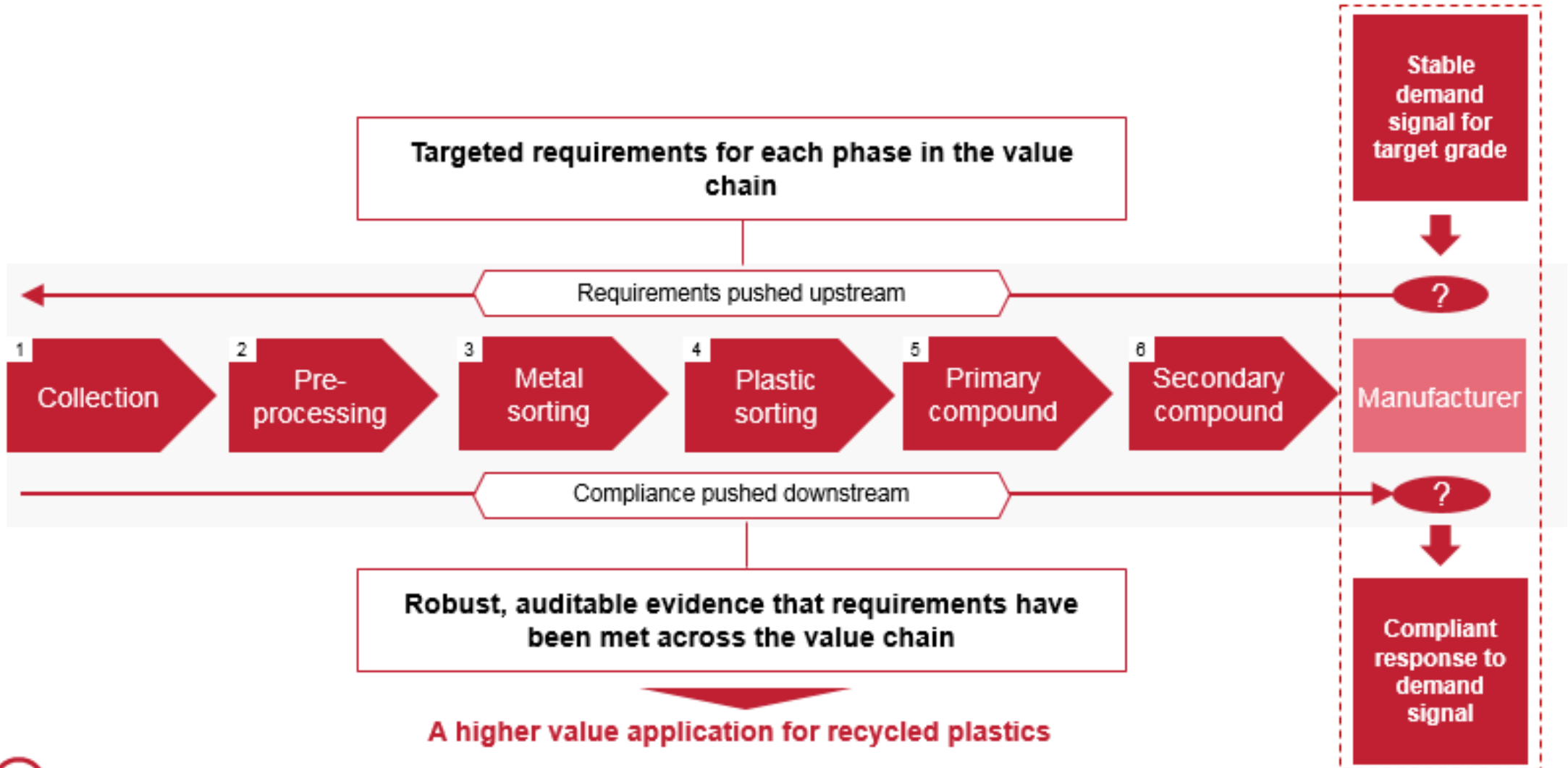
⇒ Automation is required to allow cost-efficient and systematic input testing. (from 322 to 45 € per tonne, which is considered an acceptable)

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# Defining the plastic grade ?

- Reduce mistrust between actors in the value chain

- Increase data transparency

- Support trade and sales of PCR plastics

- Integration in an the Kunststofweb online platform
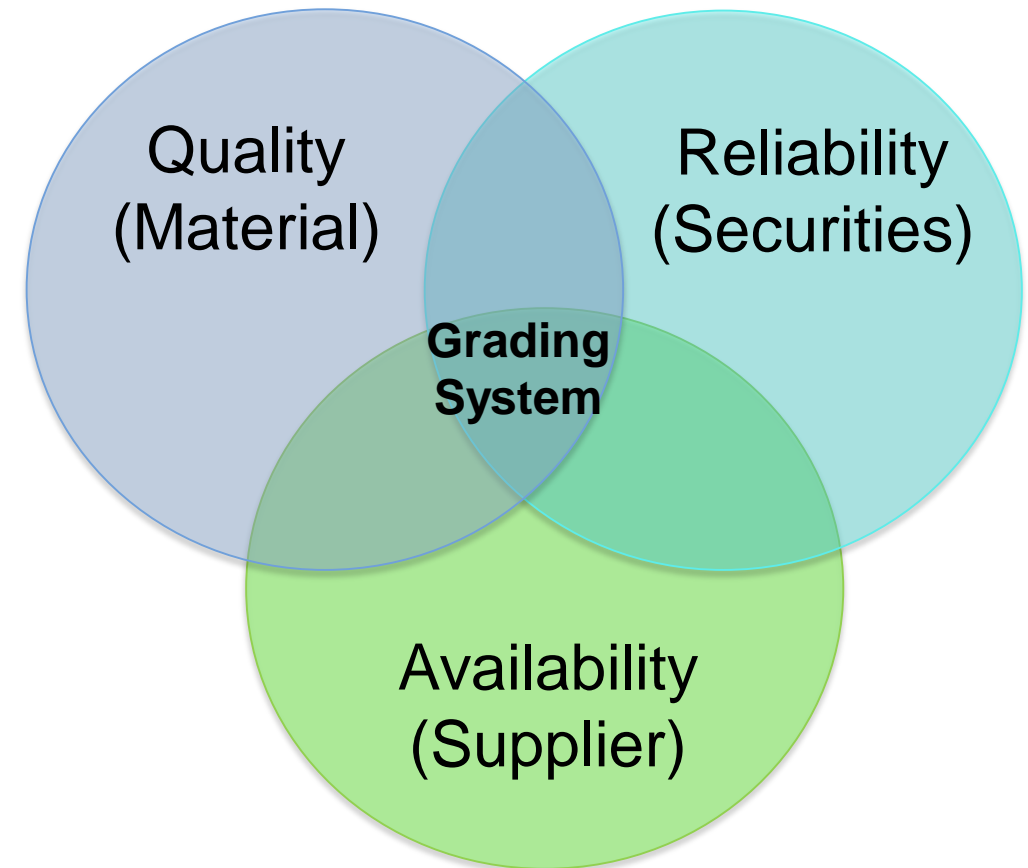
# Integration of testing procedures in Phase-Gate approach as a quality management system for the plastics recycling value chain



Targeted requirements for each phase in the value chain

Stable demand signal for target grade

Requirements pushed upstream

| 1 | 2 | 3 | 4 | 5 | 6 | |
|---|---|---|---|---|---|---|
| Collection | Pre-processing | Metal sorting | Plastic sorting | Primary compound | Secondary compound | Manufacturer |

Compliance pushed downstream

Robust, auditable evidence that requirements have been met across the value chain

Compliant response to demand signal

A higher value application for recycled plastics

Ref: BS EN 15343: Plastics recycling traceability and assessment of conformity and recycled content, EuCertPlast
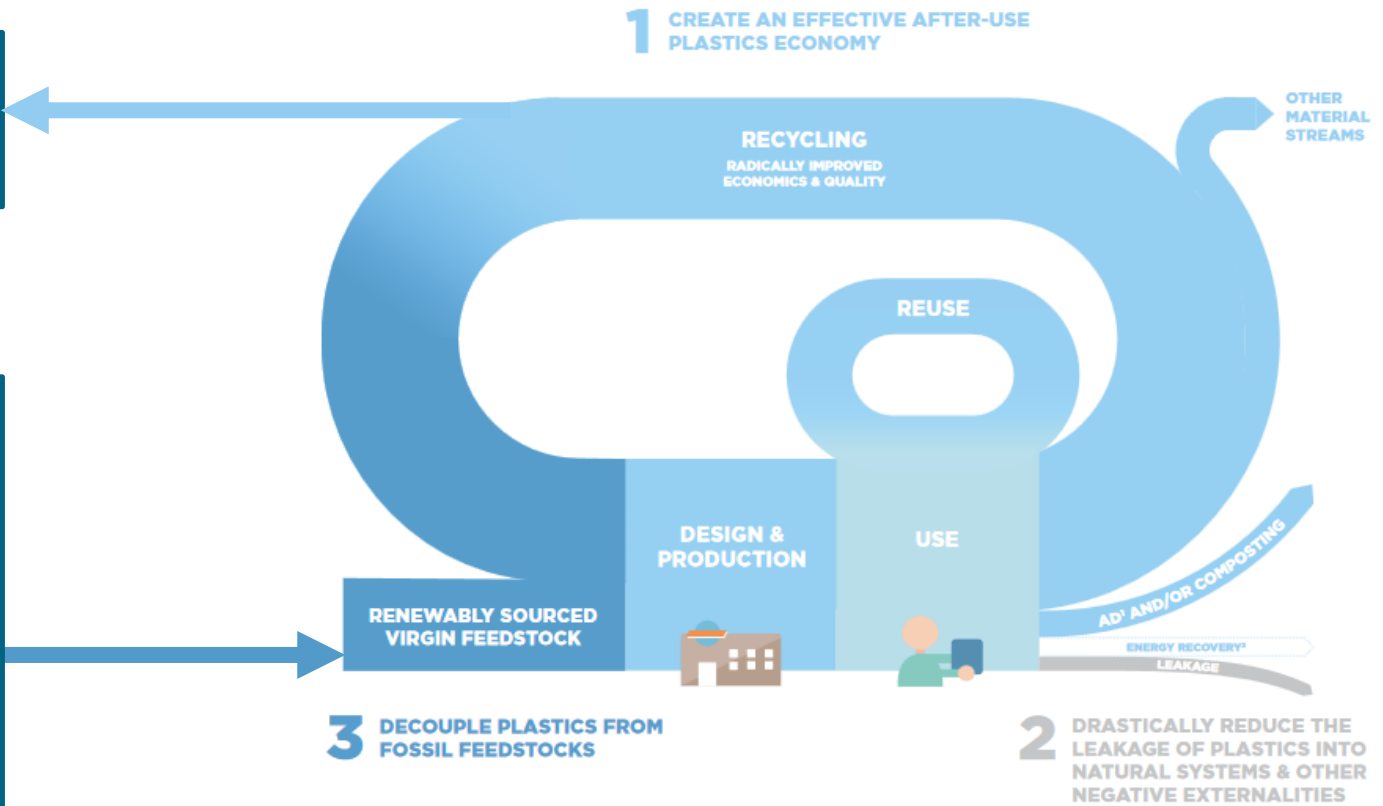
# Beyond the PolyCe project ?

The production of high quality plastics with constant quality specification and volumes requires the collaboration of the entire value chain

**Systematic quality testing and management in a Phase-Gate approach**

**+**

**Compensation of losses and quality flaws based on available information:**
-Special engineered buffer material
-Upcycling strategies
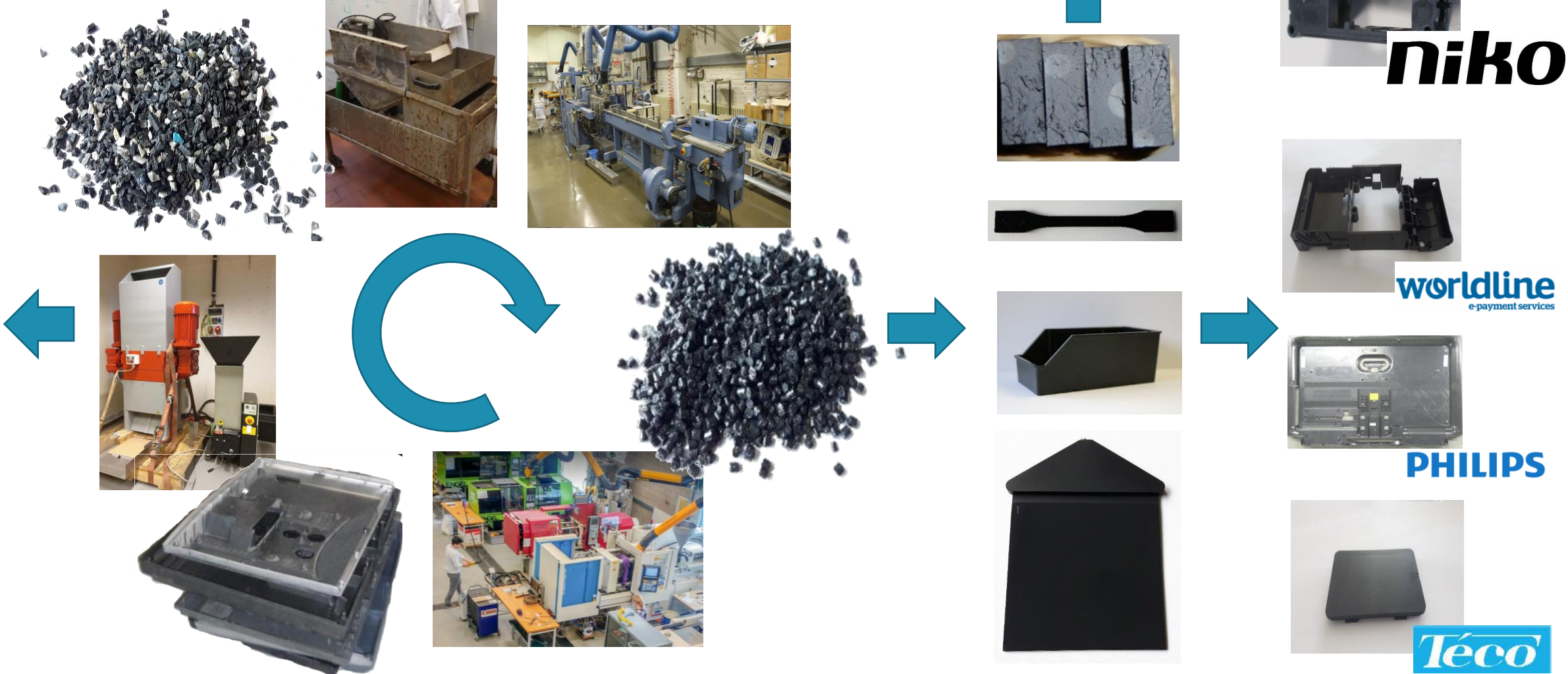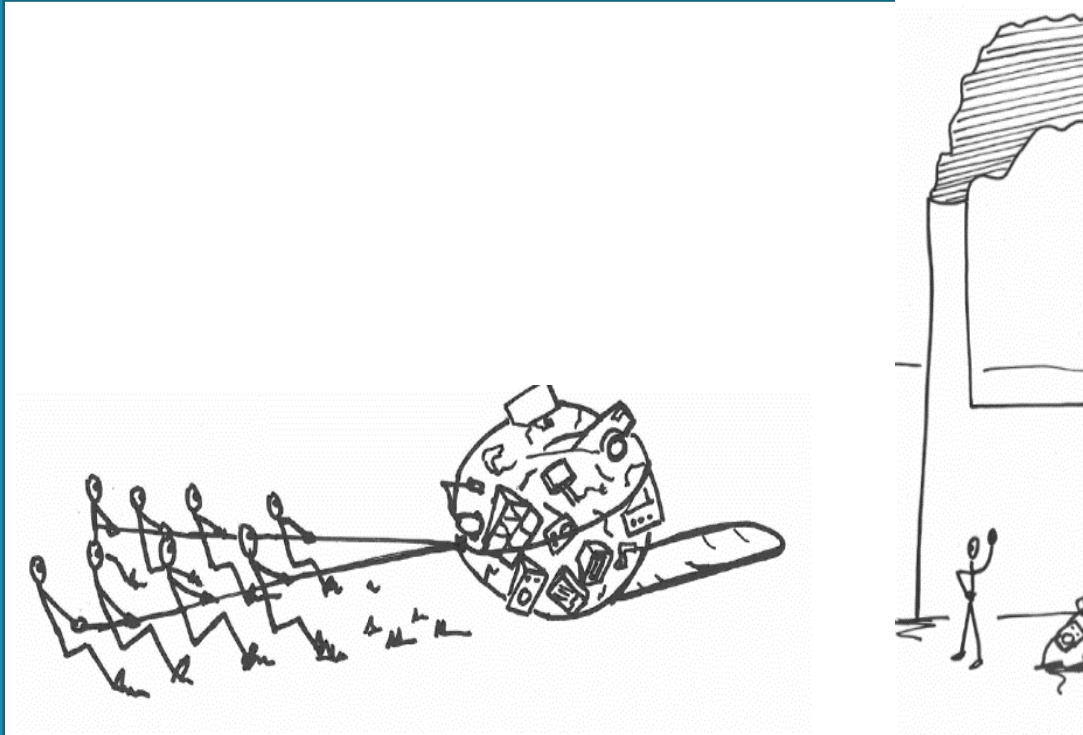-Virgin feedstock
-Chemical/dissolution based recycling



1 CREATE AN EFFECTIVE AFTER-USE PLASTICS ECONOMY

OTHER MATERIAL STREAMS

RECYCLING
RADICALLY IMPROVED ECONOMICS & QUALITY

REUSE

DESIGN & PRODUCTION

USE

RENEWABLY SOURCED VIRGIN FEEDSTOCK

AD¹ AND/OR COMPOSTING

ENERGY RECOVERY²

LEAKAGE

3 DECOUPLE PLASTICS FROM FOSSIL FEEDSTOCKS

2 DRASTICALLY REDUCE THE LEAKAGE OF PLASTICS INTO NATURAL SYSTEMS & OTHER NEGATIVE EXTERNALITIES

Ellen Macarthur Foundation

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# KU Leuven & plastic recycling

Testing

Characterization



niko

worldline
e-payment services

PHILIPS

Téco

# Questions?

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