



PolyCE

Post-Consumer High-tech Recycled Polymers for a Circular Economy

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Summary

This deliverable has the objective of collecting and reorganizing all the recommendations elaborated along the entire PolyCE project to improve circularity within the EEE sector addressing the entire value chain of EEE/WEEE plastic. Elaborating and encompassing all the outputs from previous PolyCE WPs, a coherent and comprehensive set of requirements (technical and organisational) have been identified and structured as a guideline addressing all the EEE/WEEE plastic value chain stakeholders. The guidelines have been compiled leveraging on the support of the Expert Network members and thanks to the dialogue with other relevant stakeholders engaged through consultation activities along the entire duration of the project (representing for example OEMs, take back schemes, consumers, designers, researchers, WEEE pre-processors, plastic recyclers). The guidelines are designed as a tool for transferring the knowledge acquired within PolyCE to the relevant industrial partners and to all the actors involved in the plastic chain; the guidelines will be also used as a source of information for exploitation activities, as the ones that will be implemented within WP9.

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1 Introduction

PolyCE intends to promote the use of recycled plastics in new electric and electronic equipment (EEE) and thus to reduce the use of virgin plastics. The introduction of recycled plastics in new EEE is a complex process that needs to take into account numerous aspects, such as price, availability, stability of supply. In addition, the material properties of recycled plastics are of crucial importance.

To investigate the opportunities of a more systematic approach, PolyCE has looked at each single stage of the value chain of post-consumer recycled plastics from WEEE, including collection, clustering, pre-processing, transport, sorting, recycling and compounding. The project has performed large amount of technical trials to identify the improvement potentials and has validated the feasibility of the approaches through expert interviews.

This document presents a summary of the work performed in all technical work packages (WP) and its main objective is to map the most relevant learnings that provide an important opportunity to optimize the value chain of plastics.

A number of recommendations are defined for improving the value chain of PCR plastics from WEEE.

A first screening of the status quo at the beginning of the project showed that EEE/WEEE plastic value chain actors have little feeling of the needs, requirements and working methods of the actors operating upstream and downstream. PolyCE mapped the opportunities arising from a closer collaboration and dialogue among stakeholders and developed organizational and technical solutions that can meet the requests of the value chain as a whole.

Therefore, the main aim of this report is to explain *why* and *how* to introduce improvement to the current way of designing and producing appliances, collecting and managing waste, treating and recycling plastics, selecting and buying new devices.

Guidelines are the starting point to implement solutions that can lead to a change in the plastics value chain toward circularity. The relevance of this tool lies in the environmental, social and economic assessment performed in other project WPs. The strength of the project approach is in the interdisciplinary discussions around the EEE/WEEE plastic topic it was able to generate. The interaction with industrial experts had the objective of transforming potentially beneficial solutions into concrete actions ready to be implemented from each actor of the value chain.

2 Methodology

This deliverable summarizes the outcomes from WP3, WP4, WP5, WP7, WP8 and WP9. The analysis was carried out through desk research and expert interviews.

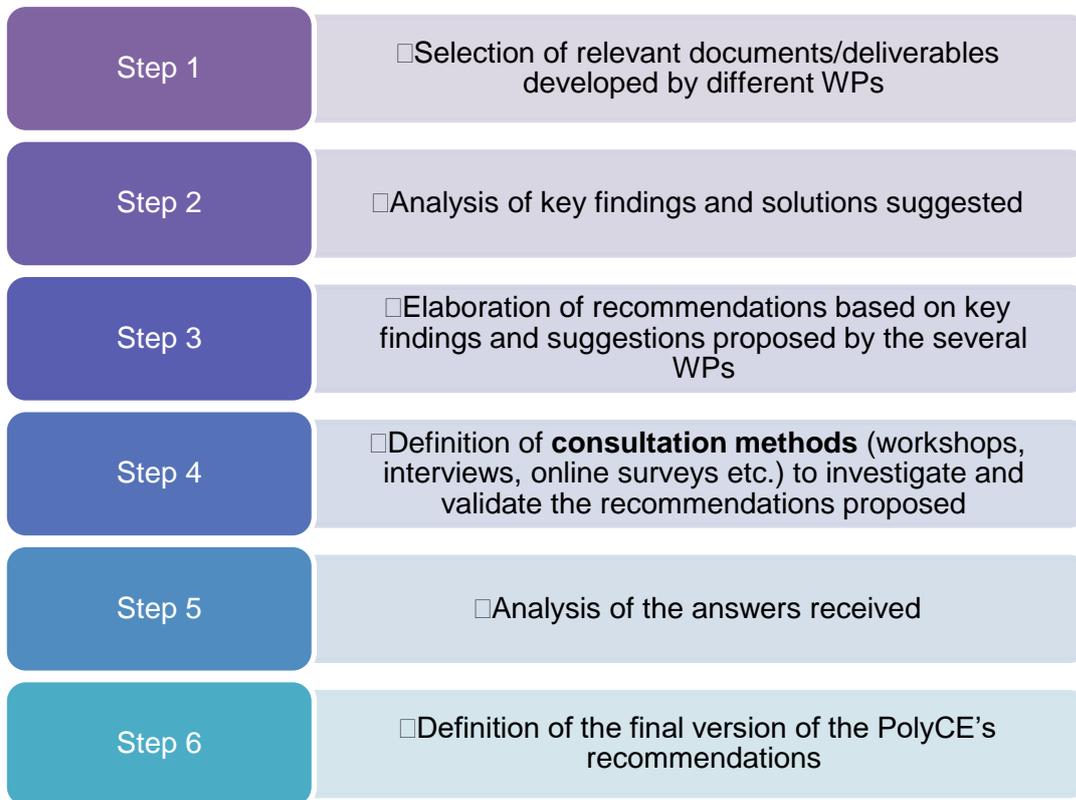


Figure 1. Task 8.8. Methodology

As presented in Figure 1, a pivotal aspect of the adopted methodology is the involvement of relevant stakeholders through **consultation activities**. Consultation activities have been conducted along the entire duration of the task on one hand to collect input regarding the stakeholders demands, on the other hand to verify the relevance, the economic and technical feasibility and the expected impacts of the solutions proposed by the project. Two main consultation initiatives have been organized to achieve task 8.8. objectives: a physical workshop and an online survey.

Physical workshop

The PolyCE workshop titled “How to Optimize Plastics Recycling to Obtain High Quality Polymers for Circular Electronics?” held during the 19th International Electronics Recycling Congress IERC 2020 (January 21 – 24, 2020 Salzburg, Austria), has been a very valuable opportunity to present PolyCE approach and preliminary findings. About

30 experts among EEE manufacturers, WEEE take back schemes, WEEE pre-treatment operators, plastic and metals recyclers from Europe as well as Canada, Japan, Rwanda and South Africa participated to the workshop.

The goal of the workshop is to elaborate together with pre-processors, recyclers and policy makers how to improve recycling steps to produce high-quality polymers which can be reused in electronic applications. Specifically, the objective of the workshop was to build a bridge between the main topics and the corresponding stakeholders reported in Figure 2. The participants were asked to actively participate in the discussion and to provide inputs.



Figure 2. IERC2020 consultation approach

Expert Network Survey

To investigate and validate the solutions collected from different work packages an online survey was organized. In detail, the key findings and suggestions collected from different WPs were used to set up the survey: a series of questions and solutions considered in the project were proposed.

The stakeholder survey was developed using “Google Form”. The survey – see Appendix 1 – was designed to take 10-15 minutes maximum to be completed and to encourage participants to provide input for the development of the guidelines. The complete list of questions and possible answers is reported in Annex I.

The survey was organized into 4 different sections according to the main project targets.

1. EEE manufacturer/ EEE designer
2. WEEE pre-treatment operator/plastic recycler/compounder

3. Academic/researcher/consultant/policy maker/representative of a compliance scheme/representative of a sustainability association
4. Other



Figure 3. Online survey

Different questions were addressed to different target groups.

It was decided to invite the members of the PolyCE's Expert Network to join the online consultation, without extending the invitation to other stakeholders through the dissemination on project social media channels and/or website. This strategy has been adopted considering that the PolyCE project is near the end, therefore the core activities have been already implemented as well as key decisions have been already taken. Expert Network have been informed continuously concerning projects development, thus they have been involved to provide a final validation on the project activities, rather than to indicate further aspect to be analyses.

The members of the Expert Network were invited via email to join the consultation contributing to design guidelines for the entire plastics value chain; the survey has been available for three weeks.

Considering that all the relevant stakeholders (project partners as well as external actors) have been informed about the project progresses and intermediate results along the entire duration of the project, it is important to take into account that the guidelines, as

output of task 8.8., include also the knowledge acquired by means of consultation initiatives different from the ones listed above, as the ones conducted within task 3.5. through interviews or within tasks 3.4. through webinars.

2.1 Consultation results

Workshop results

Workshop participants on one hand confirmed the inputs received during the consultations implemented within T3.5 activities (shortly, claiming that ensure the feasibility of the proposed solutions, particular attention should be devoted to key aspects as avoid additional manual work, take into account space constrains and procession time variation as well as consider the quality of the input material in the WEEE pre-treatment plant; moreover, according to task 3.5. findings it resulted that clustered collection strategy is difficult to implement at municipal collection points level due to space constrains, need of training the personnel, need of additional authorization, need of properly informing citizens); on the other hand, pointed out that, to ensure the economic sustainability of the PolyCE approach it is fundamental:

- to engage more consumers to facilitate cluster activity already in the collection phase;
- to explore technological solutions for the automatic sorting of products;
- to create synergies with the management of other types of waste, such as batteries and electronic components; it is also worth exploring Post Industrial plastics contribution;
- to implement practices that ensure large volumes of WEEE to be treated;
- to create incentive mechanisms for the use of recycled plastic by producers.

Expert Network Survey results

The Expert Network members provided answers to the survey; they provided also additional comments. The detailed comments of the survey are reported in Annex II.

3 Guidelines

The scope of these guidelines is to provide support to all the actors of the EEE/WEEE value chain in implementing circular economy solutions, specifically improving the quality of PCR WEEE plastics and integrating them in new equipment.

The guidelines are designed in **11 steps** to be taken by the actors involved in the value chain. In detail, steps are clustered according to **5 main topics** investigated into the project:

- **HOW TO IMPROVE THE QUALITY OF PCR WEEE PLASTICS**
 - ✓ Step 1. Improve WEEE collection and clustering
 - ✓ Step 2. Improve WEEE treatment
 - ✓ Step 3. Improve PCR plastics testing procedures
 - ✓ Step 4. Improve PCR plastics granulate productions

- **HOW TO BOOST PCR WEEE PLASTIC USE - Adopt a circular product development strategy, incl. design for and design from recycling**
 - ✓ Step 5. Adopt a design for recycling strategy
 - ✓ Step 6. Start using recycled plastics following the Three pillar approach

- **HOW TO INCREASE TRUST AMONG STAKEHOLDERS**
 - ✓ Step 7. Use a common language
 - ✓ Step 8. Use a common marketplace

- **ENGAGE CONSUMERS**
 - ✓ Step 9. Raise awareness amongst consumers
 - ✓ Step 10. Engage consumer in CE business models

- **ENGAGE POLICY MAKERS**
 - ✓ Step 11. Ask for policy changes

The steps have been designed with a common framework:

- the step is relevant for (e.g. “What can you do if you are a ...”),
- role of the actor involved, the reasons the action/s should be taken for (“Why”),
- the action/s to be taken (“DO”) with the related difficulties and constrains and
- references to technical supporting documents.

11 STEPS to Obtain Post-Consumer High-tech Recycled Polymers for a Circular Economy

How to improve the quality of PCR WEEE plastics

Step 1. Improve WEEE collection and clustering

What you can do if you are a **retailer**

Retailers should enhance the collection of WEEE through redefined product group **clustering** based on material types and properties. Currently, each WEEE stream contains various product groups with different polymer types.



Why? To facilitate recycling activities and obtain higher quality PCR plastics:
it is complicated to separate and recycle polymers coming from the treatment of mixed appliances composed by different products

DO

- take advantage of the fact that certain shops are selling specific products or brands to have a clean stream of products collected
- introduce additional bins for selected products coming from **1 Vs 1 collection** (“when supplying a new product, distributors are responsible for ensuring that such waste can be returned to the distributor at least **free of charge on a one-to-one** basis as long as the equipment is of equivalent type and has fulfilled the same functions as the supplied equipment”, *Art. 5 - as foreseen in the WEEE Directive*)



It works! ERION demonstrated the benefits of introducing two additional bins, one for printers and one for coffee machines collection, in the **MediaWorld collection point**. You can consult deliverable “Demonstrator for the WEEE supply chain” to learn more.



There are **space constrains** to consider for full implementation; moreover, retailers should be **incentivized** to participate to this collection activities and consumers should be **educated** to use this disposal channel.

Step 2. Improve WEEE treatment

What you can do if you are a **logistic operator**

Logistic operators are in charge of transporting WEEE from Collection Points to Treatment Plants. They can also play a role in circular economy transition, implementing **reverse logistic solutions** to take advantage of spare capacity currently in product end-of-life handling process.



Why? To reduce inefficiencies in current WEEE transport operations: reducing number of vehicles, fuel consumption and CO₂ emissions

DO

Introduce **Consolidation Centres** that function as an intermediary destination where goods of identical streams and destination can be stockpiled until such a point that transportation to the relevant destination can be performed at a **more optimal load-factor**



To know more about this solution, you can consult deliverable “Reverse Logistic for Environmentally Sustainable Collections, Recycling and Reuse of PCR Plastics” elaborated by **TUON**.



There are **management costs** to consider, as well as **scavenging risks** and **authorization requirements** to fulfil.

Step 2. Improve WEEE treatment

What you can do if you are a **WEEE pre-treatment operator**

Pre-treatment operators currently obtain plastic as the outcome of a negative sorting activity: target fraction of the sorting is usually another material (e.g. copper), likely more valuable. This is due to the fact that each WEEE stream contains hundreds of different products; consequently, WEEE plastic is extremely mixed, difficult to separate and then with a low market value.



Why? To provide recyclers with high-quality plastics flakes (pure and uniform streams) so that they can obtain higher quality PCR plastics:

1. facilitate the separation and recycling of polymers by smart clustering of WEEE
2. identify the most suitable flake size for subsequent sorting processes. Every sorting technology needs a specific particle size range for optimal performance

DO

- introduce **new product clusters** (treating separately specific product categories and/or specific product components)
- optimize the treatment process to obtain plastics flakes **with a size range from 10-20 mm**



It works! ERION, MGG and Whirlpool demonstrated the benefits of introducing new products clusters: 1) fridges drawers, 2) washing machines, 3) printers, 4) coffee machines and 5) vacuum cleaners, in the **WEEE pre-treatment facilities**. You can consult deliverable “Demonstrator for the WEEE supply chain” and “Whirlpool Large domestic Appliance demonstrator”. to learn more. Whirlpool produced a new washing machine drum using PCR plastics coming from washing machine cluster!



There is a request of **additional labour** and **longer processing time** as well as **space constraints** to consider for full implementation; **space and logistic** should be reorganized; treatment operators need additional **training**.

Step 3. Improve PCR plastics testing procedures

What you can do if you are a **WEEE pre-treatment operator**

The demand for recycled plastics is still relatively low due to the mistrust in the materials' capabilities of fulfilling the needs of the manufacturers. To increase the use in recycled plastics in the upcoming years it is necessary to adopt a method for qualitative assessment of mixed plastic **improving data transparency between pre-processors and recyclers as well as to increase the trade of recycled plastics**, allowing them to compare different mixed plastic quality and characteristics.



Why? To provide recyclers with useful information to evaluate the mixed plastics and perform the proper recycling activities:

1. facilitate the separation and recycling of polymers by selecting the proper recycling activities
2. improve the trading of post-consumer plastics

DO

Introduce the **grading system for recycled plastics** based on three categories (quality, reliability and availability)



To know more about this solution, you can consult deliverable "Development of a uniform grading system for post-consumer recycled plastics from WEEE" elaborated by **KUL**.



There are **additional costs** to consider, as well as the request of additional tests to be performed for specific applications.

Step 4. Improve PCR plastic granulate productions

What you can do if you are a **compounder**

Compounders represent the link between recycled and manufacturers. They should take advantage of this role to promote PCR plastic use.



Why? To produce ad hoc materials to meet the specific manufacturers' needs: manufacturers should be available to indicate to compounders the key requirements for the target materials (e.g., colour, mechanical properties). compounders will set up process conditions consequently.

DO

- establish a close collaboration with manufacturers
- set up process conditions according to manufacturers' needs
- properly use **sustainable additives**



Tecnalia, Sitraplas and Prolabin demonstrated that additives such as acid scavengers and light stabilizers based in hydrotalcites and ZrP could have a relevant role from the perspective of the circular economy in plastics. Those additives could contribute to keep the relevant properties of the polymer compounds along the time, including aging and reprocessing cycles, contributing to increase of the lifetime, avoid the natural yellowing and reducing the total carbon footprint of polymers in electric and electronic, and other sectors.



Additives contribute to the maintenance of the polymers properties along their entire life cycle. For example, the addition of the appropriate mixture of stabilizers increases the thermal-oxidative resistance of ABS for several aging and mechanical recycling steps.

How to boost PCR WEEE plastic use

Adopt a circular product development strategy, incl. design for and design from recycling

Step 5. Integrate a design for recycling strategy

What you can do if you are a *designer*

More than 80% of the environmental impact of a product is determined at the design stage¹. Products that are easy to recycle at their end of life can not only improve the yield of recyclers, but also help delivering the quality required by OEMs. For this reason, design for recyclability is a particularly important part of the EU plastics strategy.



You can adopt a **Design For Recycling** approach following the PolyCE guidelines!

Why? To facilitate recycling activities and obtain higher quality PCR plastics:

1. Avoid the use of hazardous substances
2. Enable easy access and removal of hazardous or polluting parts
3. Use recyclable materials that will be recycled by WEEE recyclers
4. Use material combinations and connections that allow easy liberation

DON'T

- Avoid > 5 different polymers in a product
- Do not use PVC and Br-FR polymers
- Do not use POM as a blend
- Avoid the use of glass fibre filled plastics
- Do not use permanent connections
- Avoid heavy coatings
- Avoid multiple-K processes



It works! Look at **Pezy** results: you can look into deliverable “Demonstrator SME EE product” and into the PolyCE book “**Practical guidelines for designers**” (check on PolyCE website <https://www.polyce-project.eu/results/>) to learn more about how Pezy applied a Design for recycling strategy in the development of the Wireless Value Comfort sensor.



All sorts of uncertainties such as cost, availability, colour freedom, lot-to-lot stability and process capability need to be reduced to a minimum to prove that the recycled material fits the business case and the technical needs of the product. Only then it will be possible to move towards large mould trials, product assembly and finally to mass production.

¹ European Commission, “Ecodesign Your Future: How Ecodesign can help the environment by making products smarter,” 2012. [Online]. Available: https://www.buildup.eu/sites/default/files/content/Brochure-Ecodesign-Your-Future-15022012_0.pdf

Step 5. Integrate a design from recycling strategy

What you can do if you are a **manufacturer**

Manufacturers are reluctant to use new, unknown materials; they are reticent in implementing circular economy principles because they are afraid of material failures and economic losses.



Why?

To successfully include PCR plastics in new products increasing circularity and support the achievement of ambitious goals established by the EU Commission

DO

- establish a close collaboration with other actors as recyclers, designers and compounders
- follow a **6 steps approach** for material PCR approval:
 1. *material selection*
 2. *property testing*
 3. *pilot moulding*
 4. *large moulding trial*
 5. *mass production!*



There are many good reasons to adopt CE solutions! PolyCE prepared a **Sales pitch for PCR plastics integration**. Which are the 5 steps to take to start a change towards CE? Have a look to them in deliverable “Value chain map of current level of circularity in EEE plastics” and to the PolyCE pamphlet available here https://www.polyce-project.eu/wp-content/uploads/2020/06/PolyCE-Deliverable-1.3_Pamphlet.pdf.



It is important to evaluate the specific characteristics of target product, the **reliability** of material quality and supply, price **stability** and **predictability**.

Step 6. Start using recycled plastics following the Three pillar approach

What you can do if you are a *designer*

Manufacturers are reticent to use materials for which they have little 'feeling' for. Designers play a key role in enhancing the use of PCR plastics in new products but sometimes they are unaware of the presence of high quality PCR recycled plastics.



Why? To increase the use of PCR plastics in new products:

1. proving to OEMs that the use of high-quality recycled plastics does not affect the quality and properties of new products
2. easily identifying recycled polymer's strengths and weaknesses
3. bridging the gap between technical datasheet and actual feel of the material

DO

- Use demo products and **dEEEterminators** to increase OEMs trust

A dEEEterminators is tactile hands-on injection moulding product; a design tool equipped with several materials and common EEE-product

- Adopt a **Drop-In Approach**: deal with one uncertainty at a time: *start with existing products, build material knowledge first, start with internal components, evaluate economic feasibility*. The **Drop-In Approach** is a practical **three pillar tool** for product developers to start designing with recycled plastics



We made it! Look at PolyCE **Design Toolbox** in deliverable "Design from Recycling strategy for PCR polymers from WEEE": it includes dEEEterminators and **the Practical guidelines for designers**. The guidelines contain all the details of the Drop-in Method consisting of a **Drop-in complexity level tool**, a **Six step material approval approach**, a **Look & learn phase**.



Recyclers need support in developing such kind of tool in accord with OEMs specifications; moreover, they need to prove that the quality of the produced PCR plastic will stay stable along the time.

How to increase trust among stakeholders

Step 7. Use a common language

What you can do if you are **WEEE pre-treatment operator**

Pre-treatment operators are not polymers specialists; however, it is necessary to adopt a method for qualitative assessment of mixed plastic improving data transparency between pre-processors and recyclers, allowing them to compare different mixed plastic quality and characteristics.



Why? To provide recyclers with proper information on material and facilitate recycling activities:

1. facilitate international communication between pre-treatment operators and recyclers
2. pre-treatment operators should facilitate recyclers evaluating the appropriate sorting technologies to be used to produce PCR plastics

DO

- tests for plastic flakes: material composition, size distribution, colour distribution, meta-data on pre-treatment process
- make available the results of tests to recyclers



It works! Look at **KUL and MGG** results: you can consult deliverable “Description of standard and systematic testing procedures for the different types of PCR” to learn more about **standard and systematic testing procedures** for the different types of PCR and harmonization of technical datasheets.



There are **time** and **costs** constrain to perform all the tests; **automated testing** solutions should be studied.

Step 7. Use a common language

What you can do if you are *plastic recycler*

Before accepting materials for the next phase in processing the material has to meet certain properties or characteristics which are determined by the final use. Currently plastic recyclers perform analysis on materials produced according to the targeted application and tests are agreed case-by-case. Recyclers should adopt standards to verify and test properties of post-consumer recycled plastics. Recyclers are able to supply good quality materials to manufacturers. They should also support OEMs to select the right one.

Why? PCR plastic requirements strongly depend on the targeted application:

1. facilitate international communication between recyclers and OEMs
2. make ease the identification of PCR for a broad variety of injection moulding and extrusion applications
3. recyclers should facilitate OEMs evaluating the applicability of compounded plastic granulates
4. control material quality consistency across the material value chain

DO

- perform test according a shortlist of uniform requirements to which PCR grades should minimally comply. Test should verify aesthetical, mechanical, physical, rheological, thermal, dimension stability, flammability, safety chemical properties
- make available the results of tests to OEMs
- adopt the **Phase Gate Approach** that allows to estimate risks related to the presence of additives/purities based on available data at the different actors of the value chain.



Read the complete list of minimum requirements identified together with researchers, OEMs and recyclers in the deliverable “Report on minimum material requirements for the trials”. Learn more about the **Phase-gate Approach** in deliverable “Description of standard and systematic testing procedures for the different types of PCR”: the goal is to increase confidence in the quality of the material, assure compliance of the material with end requirements and to do so with a minimum of additional cost.



There are **time** and **costs** constrain to perform all the tests; tests should be **hierarchical, repeated often** and implementing a **common sampling method**.

Step 8. Use a common marketplace

What you can do if you are a **plastic trader**

Currently online market platforms for plastics lack the option for dedicated specifications on recycled (PCR) plastics. Plastics traders can play an active role in enhancing the sale of PCR plastics.



Why? To find the right partners:

1. find a perfect match for your material offers & searches
2. create long term business relationships between WEEE pre-treatment operators, recyclers and OEMs.
3. stabilize the price of PCR plastics and ensure a constant quality, price and quantity of the material provided

DO

- establish a relationship with different stakeholders (pre-treatment operators, recyclers and OEMs) to collect their needs
- establishing a comprehensive marketplace which allows for technical specifications on **material quality properties, supply availability, supplier reliability** (reputation) and convenient search & match functions



PolyCE will make it work! A market platform will be tailored to recycled plastics and implemented thanks to the partner **KUNSTSTOFFWEB**. Stay informed on PolyCE website.



There are already some platforms for virgin material that are working on integrating their service portfolio. The **role of commercial traders** should be carefully evaluated as well as the availability of **stable material supply**.

Engage consumers

Step 9. Engage consumers and raise awareness

What you can do if you are a **manufacturer**

Consumers are willing to buy products made with recycled plastics: according to the PolyCE consumer survey 95% of the respondents confirmed they would buy an electronic product clearly labelled as containing recycled plastics. Manufactures can play an important role in accompanying consumers' choices.



Why? To ensure consumers can make informed decisions and accept products containing PCR recycled plastics:

1. increasing consumer willingness to pay for green products
2. meeting consumers expectation
3. leveraging on key values such as: Sustainability, Environment, Responsibility, Ethics, Empathy

DO

Develop appropriate communication campaigns to improve consumers decision-making and influence consumers' perception



Look at **PolyCE social experiment** on YouTube https://youtu.be/4b9kNdzMv_o and read the details of the consumer survey in deliverable "Consumers campaigns on the benefits of recycled plastics in new electronic products". Help PolyCE breaking stereotypes about recycled plastics!



The uptake of recycled plastics into new electronic products is not only a choice for sustainability: it provides a company with a **competitive advantage** over market players who remain linear! Discover all the **Current Level of Circularity in the EEE Sector** and the circularity benefit in the **PolyCE pamphlet** https://www.polyce-project.eu/wp-content/uploads/2020/06/PolyCE-Deliverable-1.3_Pamphlet.pdf.

Step 10. Engage consumers in CE business models

What **manufacturers** can do to engage the end consumer in a CE

According to the consumers awareness and information campaigns on circular consumption models performed during the PolyCE project almost 70% of consumers involved claim they prefer repairing an old tech product, rather than buying a new one. Manufactures can play an important role in engaging consumers in adopting the CE business models.



Why? To make informed decisions on consumptions:

1. improving awareness
2. empowering consumers in pushing circularity
3. boosting the role of consumers in pushing to shift to circularity

DO

- design a proper communication campaign
- elaborate a message which is **informative**: many of the circular businesses and initiatives, their drivers and underlying concept, will be unknown to the audience
- elaborate a message which is **inspiring, uplifting, and motivational!**



EEB is Europe's largest network of environmental citizens' organisations: they know very well how to engage consumers in new adventure. Follow the indication EEB elaborated in deliverable "Consumer campaigns on circular consumption models" to properly reach your audience with sustainability messages. Have a look to what PolyCE was able to prepare following them: <https://www.youtube.com/watch?v=FLVDZkXBDbc>.



To ensure that your communication campaign is effective, you need to properly define you audience: not everybody has the capacity or interest to explore and embrace new business models.

Step 10. Engage consumers in CE business models

What you can do if you are a **consumer**

Consumers have a role to play in enabling the Circular Economy of WEEE plastics. To be successful in this, consumers should be aware of the impacts of their consumption decisions and of the several sustainable and economically option they have. There are several options such as **reuse**, **repair**, **borrow** that could be adopted by consumers to boost Circular Economy.



Why? To make informed decisions on consumptions:

1. converting willingness to make sustainable choices to actual sustainable purchases empowering consumers in pushing circularity
2. boosting the role of consumers in pushing to shift to circularity: the role of consumers is crucial when it comes to the acceptance of products designed from recycling and the creation of markets for recyclates

DO

- Try something new!
- use official channels to get information
- learn about already existing best practices
- understand benefits of recycled plastics in electronics
- **pull demand!** and **follow the #chooserecycled** hashtag



Visit the EEB website: you can find there exiting best practices that producers are already implementing in terms of Circular Economy: <https://eeb.org/circular-future>.



Consumer attitudes towards post-consumer recycled plastics is an essential step in including consumers more effectively in the circular plastics value chain. A lot of consumers are ready for CE changes. Have a look to the results of the consumers survey in deliverable “Consumer campaign on the benefits of recycled plastics in new electronic products”.

Ask for policy changes!

Step 11. Engage policy makers

Uniform policy can have an impact on all the steps of the EEE/WEEE value chain.

<p style="text-align: center;">EEE PRODUCTION AND ECO-DESIGN</p> <p>Manufacturers of EEE can follow Design for and Design from Recycling principles and thus positively influence the market of post-consumer recycled plastics: Design for Recycling criteria should be implemented through voluntary instruments, such as GPP criteria and Ecolabel. Moreover, EEE producers can be penalized or incentivized by law base on the materials they use and the design choices they make.</p>	 <p style="text-align: center;">Implementation of legislation drivers needed!</p>
<p style="text-align: center;">WEEE COLLECTION</p> <p>Collection systems that better meet citizen's habits and allow to adopt smart clustering strategies to facilitate the processes of material separation in WEEE pre-treatment facilities should be implemented. Additional data (such as the plastic content together with the polymer and additive composition per waste category) increases the confidence that an investment into mining a special cluster pays back.</p>	 <p style="text-align: center;">Reduction of legislative barriers needed!</p>
<p style="text-align: center;">WEEE TREATMENT</p> <p>A method for the quality assessment of mixed plastic flakes is proposed between pre-processors and recyclers. Additional information, such as metadata on the pre-treatment processes, composition (e.g. plastics and metals content), plastic composition, flakes' size and colour distribution and fines content could be provided. This method for the quality assessment can be introduced in WEEE treatment standards.</p> <p>The development of a quality management system is a key factor to increase data transparency, to structure and harmonize the communication in the plastics recycling supply chain and to support the trade and sales of PCR plastic. To ensure a proper implementation at EU level, the system should be introduced in the legislation or in the existing European standards.</p> <p>Moreover, additional effort needs to be placed on enforcing current WEEE legislation.</p>	 <p style="text-align: center;">Implementation of legislative drivers needed!</p>
<p style="text-align: center;">TRANSPORT AND WASTE SHIPMENTS</p> <p>The implementation of a Consolidation Centre can be difficult due to legislative constrains:</p> <ol style="list-style-type: none"> 1. it is mandatory to avoid mix of waste collected in different municipal collection points. 	

<p>2. it is extremely difficult to obtain authorization to use an area as a Consolidation Centre.</p> <p>The <i>restriction of exports</i> of used EEE/WEEE outside EU should be revised in the waste shipments regulation as well as the setting of conditions to export of WEEE.</p> <p>The EU needs <i>Fast-Track Notifications</i> with much simpler and harmonized business processes and waste classifications and without financial guarantees required for transporting non-hazardous wastes for recycling and without huge administrative costs for notifications.</p>	<p><i>Reduction of legislative barriers needed!</i></p>
<p style="text-align: center;">RECYCLING OF WEEE PLASTICS</p> <p>The complex EU legal framework on <i>hazardous substances must be harmonized</i> to promote a Circular Economy Strategy in the current global market.</p>	<p style="text-align: center;"></p> <p style="text-align: center;"><i>Harmonization of legislation needed!</i></p>
<p> The PolyCE input and policy recommendations are summarized in Deliverable 9.5 on policy measures, environmental labelling and standardization.</p> <p> PolyCE publishes a reflection paper on EU's Plastics Strategy, two position papers on the classification of WEEE plastics as "hazardous waste" and on the recycling of black plastics as well as a report on the importance of using recycled plastics.</p>	

4 Conclusion and next steps

The integration of recycled plastics in new products has become an essential goal to ensure the transition towards circular economy. However, in the EEE/WEEE sectors, achieving this target means implementing important changes in all the steps of the EEE/WEEE plastic value chain and involving all the stakeholders and experts that are operating within it.

The guidelines that have been presented in this deliverable aspires to be a tool that these actors can use to take decisions, get inspired from existing bests practices and understand the needs of the industrial players that are operating before and after them along the value chain. Overall, guidelines are intended as an instrument that helps in reading the various technical results of the project; it is a document where it is possible to find all the information regarding the project approach and main results.

These guidelines are a comprehensive document where the entire approach and methodology of PolyCE clearly emerge; however, it is important to take into account that some of the validation activities foresee by the project are not completed yet. Namely, to be exhaustive, guidelines should be supported by environmental, social and economic assessment that gives a proper evaluation of the potential results that can be achieved implementing guidelines suggestions. For example, technical confirmation regarding the PolyCE approach impacts due to the adoption of the clusterization approach are still missing (these will be contained in deliverable 7.1 that have not been submitted yet).

Therefore, until the end of task 8.8. (M48), the guidelines will be reviewed and finalized with the addition of further inputs from ongoing project activities. Moreover, the guidelines content will be used as starting point to elaborate communication and dissemination materials (as leaflets, video, training materials...) addressing several different targets. Specifically, guidelines content will be conveyed to other EU projects working on plastic related topics, to PolyCE Expert Network members, to policy makers. For instance, the EU initiatives Circular Plastics Alliance will be reached. European Commission set an ambitious objective launching an EU-wide pledge campaign through the Circular Plastic Alliance to ensure that by 2025 10 million tonnes of recycled plastics find their way in new products on the EU markets. To achieve the ambitious goal set by the European Commission systemic solutions should be proposed, the challenge requires the involvement of several actors playing a role in the plastics value chain. Also thanks to the presented guidelines, the PolyCE's project is willing to contribute to the achievement

of the ambitious goal set by the European Commission leveraging on the experience and knowledge gained in almost four years of research and activities focused on the WEEE plastics value chain.

Annex I – The survey

- **EEE manufacturer/EEE designer**

State of the art:

PolyCE identified key prerequisites for a more effective adoption of the Circular Economy by consumers.

Q.1. Consumers have a role to play in enabling the Circular Economy of WEEE plastics. However, to be successful in this, consumers should have: 1. a wide choice of product containing PCR plastic; 2. a better education regarding sustainability, CE issues and the impacts of their consumption decisions (thus proper access to information should be ensured); 3. possibility to choose among several sustainable and economically competitive options. In your opinion:

- It is relevant, however, legislative nudging and incentives are required to push industry putting on the market more products containing PCR plastics at a competitive price.
- It is relevant, however, consumers are still too skeptical regarding to safety and quality issues regarding PCR materials.
- It is not relevant, consumers are ready. The other actors of the EEE/WEEE plastic value chain need to boost the changes towards sustainability.
- Great idea!

State of the art:

currently WEEE are collected (and transferred then to WEEE pretreatment plants) in different streams: cooling and freezing appliances, large household appliances, TV&screens, small household appliances and lamps. Each WEEE stream contains different products and it can be highly heterogeneous. It is extremely complicated then to separate and recycle polymers coming from the treatment of mixed appliances composed by hundreds of different products.

Q.2. The collection of WEEE through redefined product group clustering based on material types and properties should be enhanced also at retailers' collection level, for instance introducing additional bins for selected products such as coffee machines and printers coming from 1 Vs 1 collection. Moreover, it would be possible to take advantage of the fact that certain shops are selling specific products (e.g. coffee machines of a

certain brand) to have a clean stream of products collected (citizens can easily identify the shop as a place suitable for coffee machine disposal). In your opinion:

- It is relevant, however it would be effective only promoting consumers' behavioural change: consumers usually use the retailers' collection only for large appliances (such as fridges and washing machines).
- It is relevant, however a program of incentives should be put in place to ensure the involvement of retailers.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

currently, there are no standard quality criteria for PCR plastics, the required material performances are today mostly agreed on a case-by-case basis between the WEEE pre-processor. A short list of PCR properties to be tested and standards to be adopted can facilitate international communication between recyclers and OEMs and can make ease the identification of PCR for a broad variety of injection moulding and extrusion applications.

Q.3. Performed analyses and surveys have demonstrated that PCR plastic requirements strongly depend on the targeted application. However, gathering inputs from researchers, OEMs and recyclers, a shortlist of uniform requirements to which PCR grades should minimally comply have been compiled. Making available the results of this list of tests will facilitate OEMs evaluating the applicability of compounded plastic granulates. To the greatest extent possible a program of hierarchical testing using existing standards is envisioned which will help define the final grades of recycled content material. In your opinion:

Available and requested

Colour	Aesthetical	ISO 11664
Tensile stress at Break	Mechanical	ISO 527-2/50
Tensile Strain at Yield	Mechanical	ISO 527-2/50
Tensile Strain at Break	Mechanical	ISO 527-2/50
Flexural Modulus (23°C)	Mechanical	ISO 178
Tensile Modulus (23°C)	Mechanical	ISO 527-2/1
Tensile Strength (23°C)	Mechanical	ISO 527-2/50
Charpy Unnotched (23°C)	Mechanical	ISO 179-1eU
Charpy Notched (23°C)	Mechanical	ISO 179-1eA
Density	Physical	ISO 1183
Melt Flow Rate	Rheological	ISO 1133
Vicat Softening Point	Thermal	ISO 306/A50
Heat Deflection Temperature	Thermal	ISO 75
Shrinkage at Production	Dimensional stability	ISO 294-4
Flammability Rating	Flammability	UL94HB
RoHS Compliant	Safety	201165EU
REACH Compliance	Safety	

Requested by multiple companies

Gloss	Aesthetical	ISO 2813,
Tensile stress at yield	Mechanical	ISO 527-2
UL registered	Others	
Filler content	Purity and chemical properties	ISO 3541-4
Food contact approval	Safety	EC 10/2011

Considered relevant by research

Recycled Content	History	EN 15343
Transparency in preparation and testing	Specimen preparation	ISO 19069, ISO 19062, ISO 2580, ISO 19063, ISO 7391, ISO 293, ISO 20753, ISO 294

- It is relevant, however it is too costly and time consuming to perform all the requested tests.
- It is relevant, however to perform the test required a standard containing the sampling methodology should be also developed. Moreover the tests should be repeated often due to the high variability of the input materials.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to the PolyCE findings, there is a lack of communication between manufacturers (buyers) and plastic recyclers (sellers) and between recyclers and WEEE treatment operators. This lack of communication makes it difficult to find the rights partners and to create a long-term business relationship representing one of the barriers for PCR WEEE plastic uptake.

Q.4. An online comprehensive marketplace for PCR WEEE plastic should be established because it would help stabilize the material price and ensure constant material quality. The online marketplace should contain for each material put on the market a technical specification sheet reporting information on: material specification (quick identification of necessary material properties), material availability (long term availability is today a barrier), material (score system) and supplier reliability (reputational information). In your opinion:

- It is relevant, however the online marketplace should just be a tool to obtain information regarding PCR plastics not to buy them. Commercial managers should trade relations.
- It is relevant, however without guaranteeing a stable supply, the platform couldn't be a relevant tool for enhancing the use of PCR plastics.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

designers are key actors to promote products' sustainability and they have different options to do so.

Q.5. According to PolyCE findings, introducing modularity in design could reduce the overall discard of products thanks to the replacement of the damaged parts and could be beneficial for recycling as parts can easily break apart during the shredding phase. In your opinion:

- It is relevant, however it will be beneficial only if a considerable amount of manufacturers would adopt this strategy.

- It is relevant, however there are technical and economic barriers to implement this recommendation and there is a strategy feasible only for specific products.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE findings, a typical plastic fraction consists of a large variety of other polymers and impurities making it challenging to separate them by means of cost-effective technologies available. The presence of a large variety of polymers for example affects PCR plastics quality.

Q.6. A priority plastics guide for non-FR plastics to be used by designers of electrical and electronic equipment at the conception stage, can facilitate plastics recycling at the product's end of life. In the table are summarized the main guideline categories on avoidance of toxics (hazardous substances and components) and material purification as well as less material variety (polymers and non-hazardous additives). In your opinion:

Hazardous substances and components	Polymers and non-hazardous additives
<ul style="list-style-type: none"> • Do not use substances of very high concern (SVHC) according to REACH and no substances classified carcinogenic (Carc. 1A or 1B), mutagenic (Muta 1A or 1), reprotoxic (Repr. 1A or 1B) by CLP Regulation in housing/housing parts. • Do not use any substances that are listed in the CARACAL list (Competent Authorities for REACH and Classification and Labelling) in the product. • Concentrate hazardous components to one module / a restricted location to facilitate manual removal. • When fixing hazardous or polluting components (e.g. batteries) in a product, use easily detachable solutions (e.g. click/snap) instead of permanent fixing such as adhesives. 	<ul style="list-style-type: none"> • Use only common and easily recyclable plastics (ABS, PC, PC/ABS, PP, HIPS, PA). • Do not use thermosets. If thermosets are necessary they should have another density than the common plastics used. • Do not use elastomers. If elastomers are necessary, they should have another density than the common plastics used. • Do not use halogenated polymers (e.g. PVC, PTFE). • Do not use heavy metal based lubricants and plasticisers. • Do not use Polyoxymethylene (POM). • Do not use silicone compounds, oils or greases. • Do not use montanic acid ester. • Avoid coatings (painting, lacquering, plating, galvanizing) • Do not use glass fibres or carbon fibres. If reinforcement is needed, prefer talc. • Avoid moulding different plastic types together by 2K or xK processes. • Use one single polymer in plastic casing parts >100g. • Avoid using connections that enclose a material permanently.

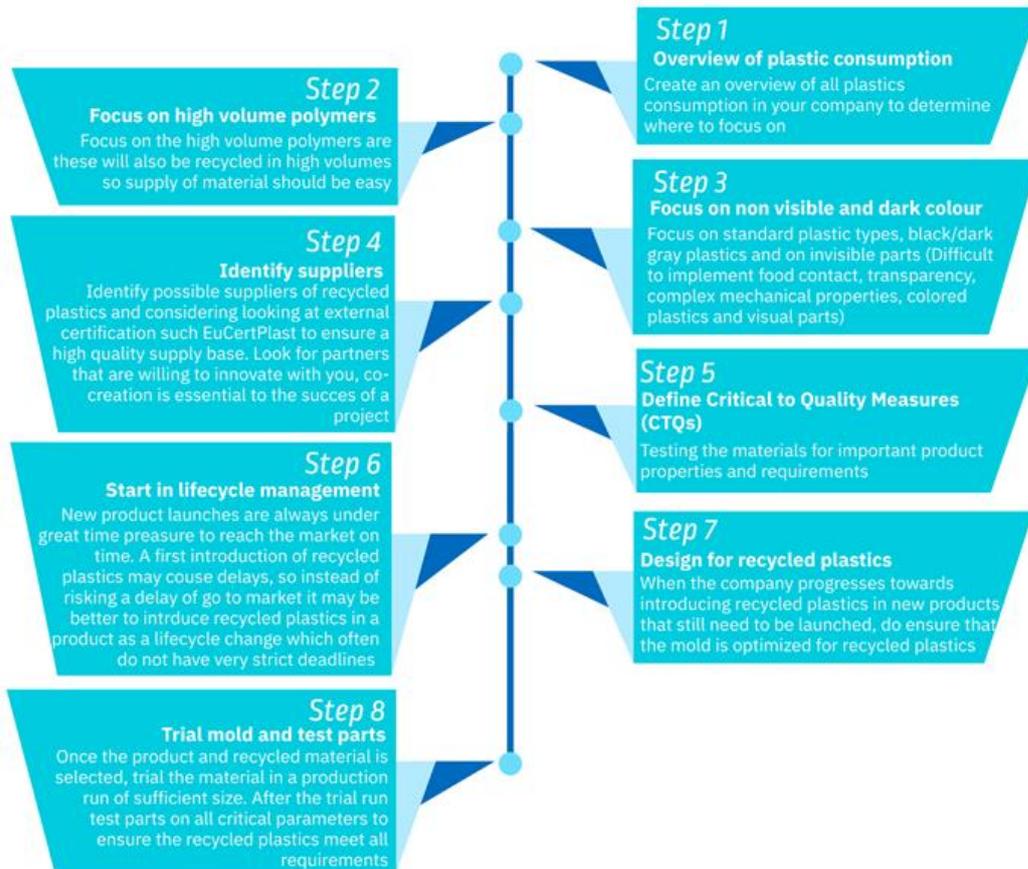
- It is relevant, however there are aesthetic and functional requirements that will make following these guidelines extremely difficult. Colour freedom/transparency/food contact grade is still a big challenge to use PCR plastic.
- It is relevant, however the indication regarding particular aspects of the product development, for example material choices, are made by OEMs and are closely related to economic evaluation.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.

- Great idea!

State of the art:

manufactures can be reticent in implementing circular economy principles in their productions because they are afraid of failures and economic losses.

Q.7. Manufacturers should follow a 8 steps approach to successfully implement circular products. In your opinion:

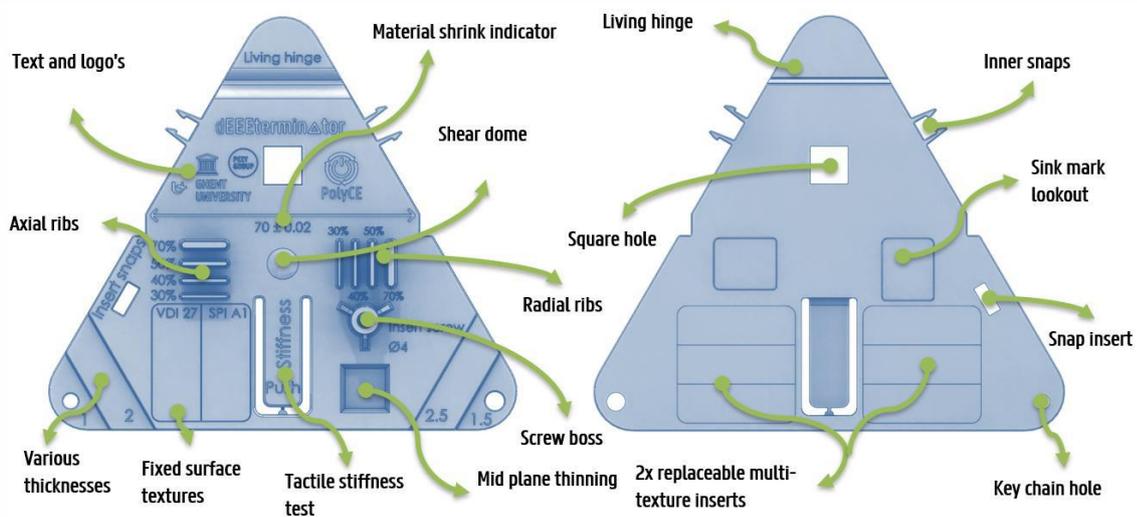


- It is relevant, however this approach is strongly dependent on the target products.
- It is relevant, however reliability of the material quality and supply, as well as price stability and predictability compared to virgin plastic material are a major concern of OEMs.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great Idea!

State of the art:

according to PolyCE findings, there is a gap in the communication between manufacturers (buyers) and plastic recyclers (sellers). Manufacturers are reticent to use materials for which they have little ‘feeling’ for. Technical data sheets are typically not adequate to make a decision. It is tempting to fall back on previous knowledge and choose within a set of standard used materials.

Q.8. Strategic tools have been developed to facilitate the effective incorporation of recycled WEEE plastics into high quality new EEE products. A “dEEETerminator” and demo products have been found to be useful tools useful to test the properties of the recycled plastics. In your opinion:



- It is relevant, however the stable supply in terms of quality is not guaranteed, therefore manufacturers cannot be sure that the properties presented through the “dEEETerminator” will stay stable along the time.
- It is relevant, however demo products should be produced in accordance with manufacturers’ technical requirements to be an effective tool.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

additives should not be considered just as potentially hazardous materials. The incorporation of additives in PCR WEEE plastic can improve the properties of materials and boost PCR WEEE plastic quality use.

Q.9. Manufacturers and compounders should closely collaborate: this would allow compounders to produce ad hoc materials to meet the specific manufacturers' needs. Manufacturers should be available to indicate to compounders the key requirements for the target materials (e.g. colour, mechanical properties); compounders will set up process conditions consequently. In your opinion:

- It is relevant, however collaboration between manufactures and compounders is already well established, there are other relevant issues to be faced.
- It is relevant, however manufactures should be willing to accept some compromise in term of properties of the recycled material.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE findings, the current WEEE/EEE plastic value chain is characterized by mistrust between actors and lack of data transparency. This makes it difficult to maintain the control on the quality of recycled material, it's important to define quality tools to be used at every stage of the EEE/WEEE supply chain.

Q.10 The development of a quality management system is a key factor to increase data transparency, to structure and harmonize the communication in the plastics recycling supply chain and to support the trade and sales of PCR plastic. A uniform grading system for PCR plastics has been developed. In your opinion, the introduction of a grading system:

- It is relevant, however, there are already systems in place to control the quality of the PCR plastic along the entire value chain.

- It is relevant, however, to ensure a proper implementation at EU level, the system should be introduced in the legislation or in the existing European standards, such as the CENELEC one.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

.....

- **WEEE pre-treatment operator/plastic recycler/compounder**

State of the art:

WEEE collection needs to be quantitatively and qualitatively improved to boost the production of WEEE PCR plastic. WEEE are collected (and transferred then to WEEE pre-treatment plants) in different streams: cooling and freezing appliances, large household appliances, TV&screens, small household appliances and lamps. Each WEEE stream contains different products. The small household appliances waste stream is the most heterogeneous one and is composed of a very large variety of products. Consequently, it is extremely complicated to separate and recycle polymers coming from the treatment of mixed appliances composed by hundreds of different products.

Q.1. Smart clustering strategies (based on material types and properties) implemented at collection level can facilitate the processes of material separation in WEEE pre-treatment facilities. In your opinion:

- Clusterization strategy should be implemented only at WEEE pre-treatment facility level.
- Clusterization strategy should be implemented at retailers level.
- Clustered collection is difficult to implement at municipal collection points level due to space constrains, need of training the personnel, need of additional authorization, need of properly informing citizens.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

currently WEEE are collected (and transferred then to WEEE pretreatment plants) in different streams: cooling and freezing appliances, large household appliances, TV&screens, small household appliances and lamps. Each WEEE stream contains different products and it can be highly heterogeneous. It is extremely complicated then to separate and recycle polymers coming from the treatment of mixed appliances composed by hundreds of different products.

Q.2. The collection of WEEE through redefined product group clustering based on material types and properties should be enhanced also at retailers' collection level, for instance introducing additional bins for selected products such as coffee machines and printers coming from 1 Vs 1 collection. Moreover, it would be possible to take advantage of the fact that certain shops are selling specific products (e.g. coffee machines of a certain brand) to have a clean stream of products collected (citizens can easily identify the shop as a place suitable for coffee machine disposal). In your opinion:

- It is relevant, however it would be effective only promoting consumers' behavioural change: consumers usually use the retailers' collection only for large appliances (such as fridges and washing machines).
- It is relevant, however a program of incentives should be put in place to ensure the involvement of retailers.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

there are inefficiencies in current WEEE transport operations. Inefficiencies arise where, to transport WEEE from collection points to treatment plants, the logistic system relies on single-lane transportation where vehicle load factors may not be optimal.

Q.3. A new node within the transportation network should be introduced: a Consolidation centre that functions as an intermediary destination where goods of identical streams and destinations can be stockpiled until such a point that transportation to the relevant destination can be performed at a more optimal load-factor, reducing logistic costs and emissions. Consolidation Centres can be potentially designed as the place where clusterization activities are performed: operators of Consolidation Centre that currently

optimize input WEEE in terms of quantity, can optimize them also in terms of quality, sorting products according to homogeneous flows. In your opinion:

- It is relevant, however the introduction of a consolidation centre is associated with additional investments and high cost of management (for example to improve security control and avoid scavenging). Who is going to pay for this extra cost?
- It is relevant, it is extremely difficult to obtain authorization (especially in certain location) to use an area as a Consolidation Centre, namely a place where WEEE are stocked and handled.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

currently WEEE pre-treatment plants receive WEEE collected in different streams: cooling and freezing appliances, large household appliances, TV&screens, small household appliances and lamps. Each WEEE stream contains different products and it can be highly heterogeneous and it is extremely complicated to separate and recycle polymers coming from the treatment of mixed appliances composed by hundreds of different products.

Q.4. According to PolyCE findings, introducing clusters is potentially beneficial in terms of PCR plastic quality improvement. The treatment of WEEE through redefined product group clustering based on material types and properties should be enhanced also at pre-processor level. Selected products should be identified and separated from other waste; for example washing machines or coffee machines. In your opinion:

- It is relevant, however the separation it's a time-consuming and expansive activity, retailers and municipal collection points can be most effective in performing the clustering activity.
- It is relevant, however working methods, logistic activities and spaces should be reorganized.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to investigation on modifiable parameters in the WEEE plastics pre-treatment processes, it resulted that on one hand it's very difficult for a preprocessor to obtain a homogeneous particle size range; on the other hand, it resulted that the sortability and the recyclability of the plastics is influenced by the adopted pre-processing approach, (different sorting technologies require different particle size ranges for efficient separation). If a sorting technology cannot separate plastics properly due to the wrong particle size, the target fraction may get into the fraction to be disposed of and thus be lost.

Q.5. To improve the volumes and quality of the plastics materials delivered to postconsumer plastics recycling facilities and increase recyclability, it is recommended defining a standard particle size (10-20 mm) for the output fraction (plastic flakes) and reducing the number of shredding steps. In your opinion:

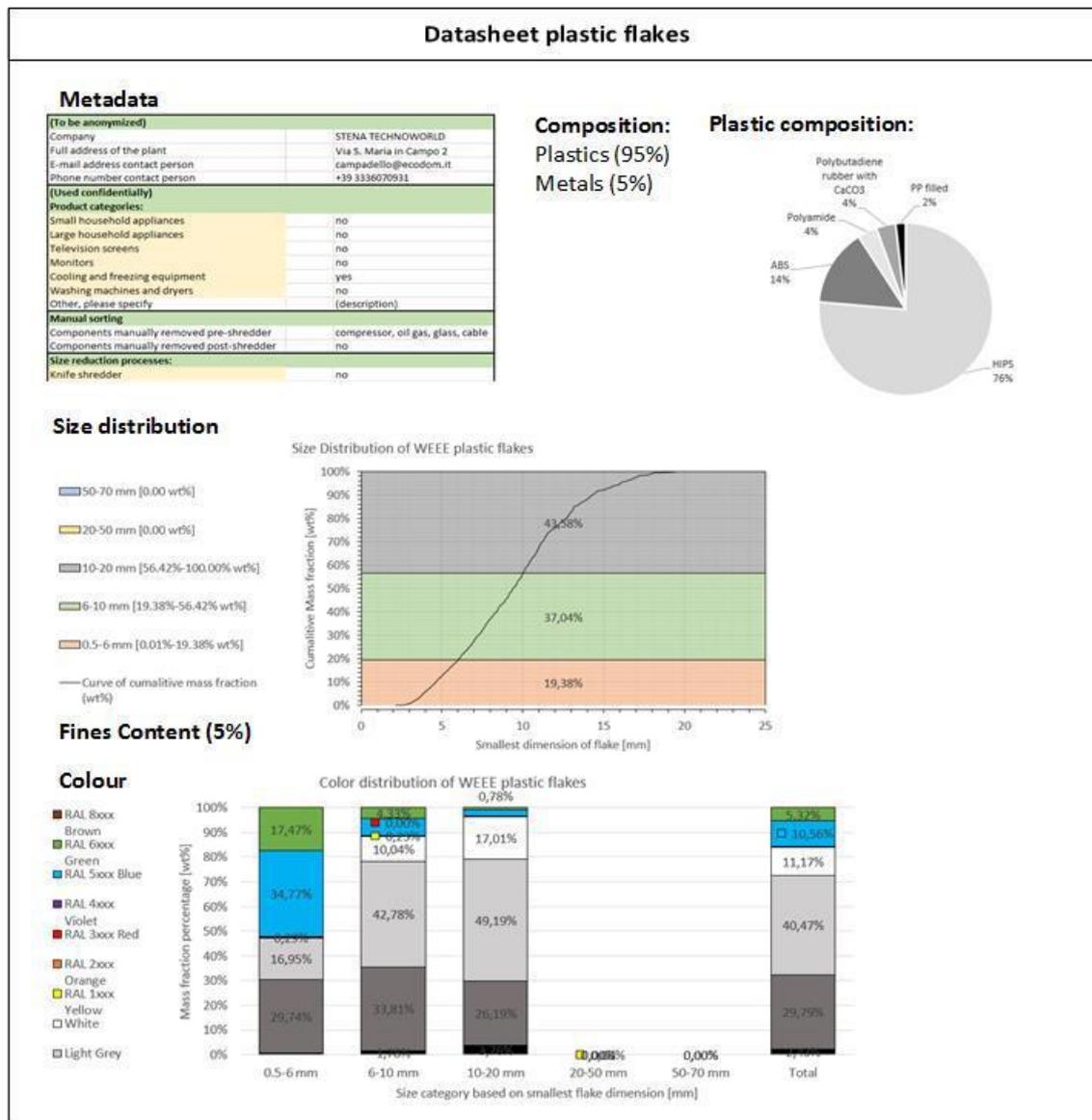
- It is relevant, however this can be a costly solutions: to obtain such small flakes, plastics should stay in the shredders longer and additional shredding steps are needed.
- It is relevant, however technologies are constantly evolving and to meet plastic sorters needs, WEEE pre-treatment operators should do relevant investments.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

the WEEE pre-treatment companies are not specialists for polymers; furthermore, the low value of the polymers on average makes them a less focused stream. Consequently, difficult for recyclers to select the most appropriate sorting technology to be adopted as well as to properly valorize different materials.

Q.6. A method for the quality assessment of mixed plastic flakes is proposed between pre-processors and recyclers, which is often subject to trade. Minimum requirement for mixed plastic flakes should be tested: material composition (to evaluate impurities content), size distribution (to evaluate the amount of materials that cannot be sorted) and colour distribution should be analysed. Additional metadata on the pre-treatment processes should be provided, compiling a sort of material identity card as the one proposed. In your opinion:

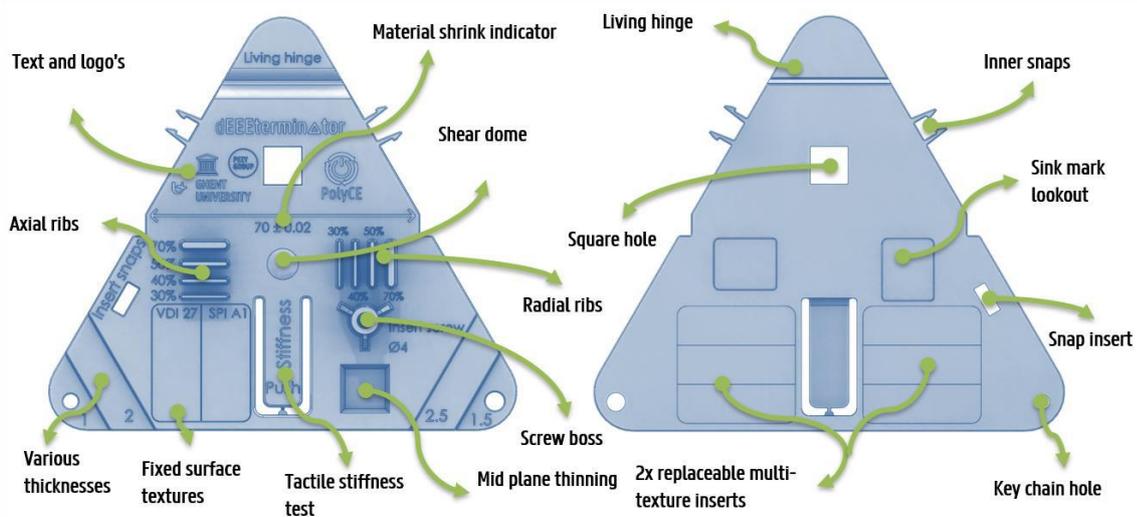
- It is relevant, however it is too costly and time consuming to perform all the requested tests.
- It will be feasible only when automated testing methods will be implemented.
- It is relevant, however there are already established methods to exchange information with plastic recyclers regarding plastic flakes quality.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!



State of the art:

according to PolyCE findings, manufacturers are reluctant to use new, unknown materials and technical data sheets are an inadequate tool to convince manufactures to use recycled material in their products. The presence of high quality PCR recycled plastics is often thought of as non-existent: product designers should be introduced to these materials and their potentiality.

Q.7. Strategic tools have been developed to facilitate the effective incorporation of recycled WEEE plastics into high quality new EEE products. A “dEEeterminator” (a tactile hands-on injection moulding product; a design tools equipped with several materials evaluating and common EEE-product features, as the one presented in the image) and demo products (e.g. simple card holder, its high quality finish and functionality lend it perfectly for an convincing first impression.) should be produced as tools to promote the recycled materials and display their relevant properties, bridging the gap between a dry and scientific technical datasheet and the actual “feel” of the material. In your opinion:



- It is relevant, however recyclers need support to develop such kinds of tools.
- It is relevant, however, beside the technical datasheet, recyclers have already established methodologies to show materials properties to designers.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE outcomes, PCR plastics originating from the WEEE stream do not always meet requirements. To avoid the use of virgin material, it's worth exploring PIR plastics or other product waste streams (ELV, packaging, furniture).

Q.8. To increase the use of recycled plastic, synergies should be created among different sources of material (e.g. PCR and PIR plastics or plastics from different waste streams). In your opinion:

- It is relevant, however the amount of material collected and recycled is still too low to ensure a stable supply in terms of quantities and quality.
- It is relevant, however without an online platform it's very hard to find new opportunities and create synergies between stakeholders of different value chains.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

additives should not be considered just as potentially hazardous materials. The incorporation of additives in PCR WEEE plastic can improve the properties of materials and boost PCR WEEE plastic quality use.

Q.9. Manufacturers and compounders should closely collaborate: this would allow compounders to produce ad hoc materials to meet the specific manufacturers' needs. Manufacturers should be available to indicate to compounders the key requirements for the target materials (e.g. colour, mechanical properties); compounders will set up process conditions consequently. In your opinion:

- It is relevant, however collaboration between manufactures and compounders is already well established, there are other relevant issues to be faced.
- It is relevant, however manufactures should be willing to accept some compromise in term of properties of the recycled material.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE findings, the current WEEE/EEE plastic value chain is characterized by mistrust between actors and lack of data transparency. This makes it difficult to maintain the control on the quality of recycled material, it's important to define quality tools to be used at every stage of the EEE/WEEE supply chain.

Q.10. The development of a quality management system is a key factor to increase data transparency, to structure and harmonize the communication in the plastics recycling supply chain and to support the trade and sales of PCR plastic. A uniform grading system for PCR plastics has been developed. In your opinion, the introduction of a grading system:

- It is relevant, however, there are already systems in place to control the quality of the PCR plastic along the entire value chain.
- It is relevant, however, to ensure a proper implementation at EU level, the system should be introduced in the legislation or in the existing European standards, such as the CENELEC one.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

-
- **Academic/researcher/consultant/policy maker/representative of a compliance scheme/representative of a sustainability association**

State of the art:

PolyCE identified key prerequisites for a more effective adoption of the Circular Economy by consumers.

Q.1. Consumers have a role to play in enabling the Circular Economy of WEEE plastics. However, to be successful in this, consumers should have: 1. a wide choice of product containing PCR plastic; 2. a better education regarding sustainability, CE issues and the impacts of their consumption decisions (thus proper access to information should be ensured); 3. possibility to choose among several sustainable and economically competitive options. In your opinion:

- It is relevant, however, legislative nudging and incentives are required to push industry putting on the market more products containing PCR plastics at a competitive price.
- It is relevant, however, consumers are still too skeptical regarding to safety and quality issues regarding PCR materials.
- It is not relevant, consumers are ready. The other actors of the EEE/WEEE plastic value chain need to boost the changes towards sustainability.
- Great idea!

State of the art:

WEEE collection needs to be quantitatively and qualitatively improved to boost the production of WEEE PCR plastic. WEEE are collected (and transferred then to WEEE pre-treatment plants) in different streams: cooling and freezing appliances, large household appliances, TV&screens, small household appliances and lamps. Each WEEE stream contains different products. The small household appliances waste stream is the most heterogeneous one and is composed of a very large variety of products. Consequently, it is extremely complicated to separate and recycle polymers coming from the treatment of mixed appliances composed by hundreds of different products.

Q.2. Smart clustering strategies (based on material types and properties) implemented at collection level can facilitate the processes of material separation in WEEE pre-treatment facilities. In your opinion:

- Clusterization strategy should be implemented only at WEEE pre-treatment facility level.
- Clusterization strategy should be implemented at retailers level.
- Clustered collection is difficult to implement at municipal collection points level due to space constraints, need of training the personnel, need of additional authorization, need of properly informing citizens.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

currently WEEE are collected (and transferred then to WEEE pretreatment plants) in different streams: cooling and freezing appliances, large household appliances, TV&screens, small household appliances and lamps. Each WEEE stream contains different products and it can be highly heterogeneous. It is extremely complicated then to separate and recycle polymers coming from the treatment of mixed appliances composed by hundreds of different products.

Q.3. The collection of WEEE through redefined product group clustering based on material types and properties should be enhanced also at retailers' collection level, for instance introducing additional bins for selected products such as coffee machines and printers coming from 1 Vs 1 collection. Moreover, it would be possible to take advantage of the fact that certain shops are selling specific products (e.g. coffee machines of a certain brand) to have a clean stream of products collected (citizens can easily identify the shop as a place suitable for coffee machine disposal). In your opinion:

- It is relevant, however it would be effective only promoting consumers' behavioural change: consumers usually use the retailers' collection only for large appliances (such as fridges and washing machines).
- It is relevant, however a program of incentives should be put in place to ensure the involvement of retailers.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art: there are inefficiencies in current WEEE transport operations.

Inefficiencies arise where, to transport WEEE from collection points to treatment plants, the logistic system relies on single-lane transportation where vehicle load factors may not be optimal.

Q.4. A new node within the transportation network should be introduced: a Consolidation centre that functions as an intermediary destination where goods of identical streams and destinations can be stockpiled until such a point that transportation to the relevant destination can be performed at a more optimal load-factor, reducing logistic costs and emissions. Consolidation Centres can be potentially designed as the place where clusterization activities are performed: operators of Consolidation Centre that currently

optimize input WEEE in terms of quantity, can optimize them also in terms of quality, sorting products according to homogeneous flows. In your opinion:

- It is relevant, however the introduction of a consolidation centre is associated with additional investments and high cost of management (for example to improve security control and avoid scavenging). Who is going to pay for this extra cost?
- It is relevant, it is extremely difficult to obtain authorization (especially in certain location) to use an area as a Consolidation Centre, namely a place where WEEE are stocked and handled.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

currently WEEE pre-treatment plants receive WEEE collected in different streams: cooling and freezing appliances, large household appliances, TV&screens, small household appliances and lamps. Each WEEE stream contains different products and it can be highly heterogeneous and it is extremely complicated to separate and recycle polymers coming from the treatment of mixed appliances composed by hundreds of different products.

Q.5. According to PolyCE findings, introducing clusters is potentially beneficial in terms of PCR plastic quality improvement. The treatment of WEEE through redefined product group clustering based on material types and properties should be enhanced also at pre-processor level. Selected products should be identified and separated from other waste; for example washing machines or coffee machines. In your opinion:

- It is relevant, however the separation it's a time-consuming and expansive activity, retailers and municipal collection points can be most effective in performing the clustering activity.
- It is relevant, however working methods, logistic activities and spaces should be reorganized.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to investigation on modifiable parameters in the WEEE plastics pre-treatment processes, it resulted that on one hand it's very difficult for a pre-processor to obtain a homogeneous particle size range; on the other hand, it resulted that the sortability and the recyclability of the plastics is influenced by the adopted pre-processing approach, (different sorting technologies require different particle size ranges for efficient separation). If a sorting technology cannot separate plastics properly due to the wrong particle size, the target fraction may get into the fraction to be disposed of and thus be lost.

Q.6. To improve the volumes and quality of the plastics materials delivered to postconsumer plastics recycling facilities and increase recyclability, it is recommended defining a standard particle size (10-20 mm) for the output fraction (plastic flakes) and reducing the number of shredding steps. In your opinion:

- It is relevant, however this can be a costly solutions: to obtain such small flakes, plastics should stay in the shredders longer and additional shredding steps are needed.
- It is relevant, however technologies are constantly evolving and to meet plastic sorters needs, WEEE pre-treatment operators should do relevant investments.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

the WEEE pre-treatment companies are not specialists for polymers; furthermore, the low value of the polymers on average makes them a less focused stream. Consequently, difficult for recyclers to select the most appropriate sorting technology to be adopted as well as to properly valorise different materials.

Q.7. A method for the quality assessment of mixed plastic flakes is proposed between pre-processors and recyclers, which is often subject to trade. Minimum requirement for mixed plastic flakes should be tested: material composition (to evaluate impurities content), size distribution (to evaluate the amount of materials that cannot be sorted) and colour distribution should be analysed. Additional metadata on the pre-treatment processes should be provided, compiling a sort of material identity card as the one proposed. In your opinion:

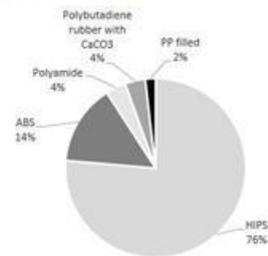
Datasheet plastic flakes

Metadata

(To be anonymized)	
Company	STENA TECHNO WORLD
Full address of the plant	Via S. Maria in Campo 2
E-mail address contact person	campadello@ecodom.it
Phone number contact person	+39 3336070931
(Used confidentially)	
Product categories:	
Small household appliances	no
Large household appliances	no
Television screens	no
Monitors	no
Cooling and freezing equipment	yes
Washing machines and dryers	no
Other, please specify	(description)
Manual sorting	
Components manually removed pre-shredder	compressor, oil gas, glass, cable
Components manually removed post-shredder	no
Size reduction processes:	
Knife shredder	no

Composition:
Plastics (95%)
Metals (5%)

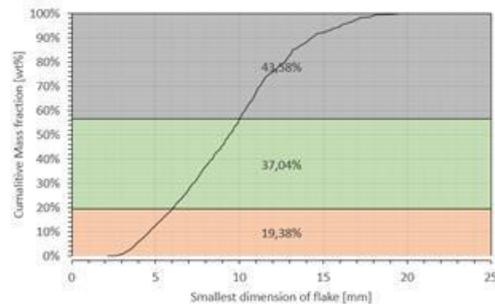
Plastic composition:



Size distribution

50-70 mm	[0.00 wt%]
20-50 mm	[0.00 wt%]
10-20 mm	[56.42%-100.00% wt%]
6-10 mm	[19.38%-56.42% wt%]
0.5-6 mm	[0.01%-19.38% wt%]
— Curve of cumulative mass fraction (wt%)	

Size Distribution of WEEE plastic flakes

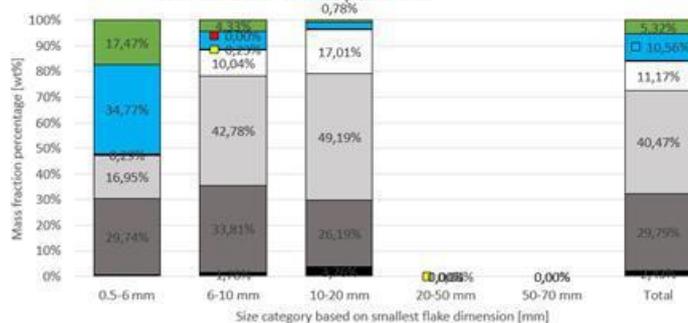


Fines Content (5%)

Colour

RAL 800x
Brown
RAL 600x
Green
RAL 500x Blue
RAL 400x
Violet
RAL 300x Red
RAL 200x
Orange
RAL 100x
Yellow
White
Light Grey

Color distribution of WEEE plastic flakes



- It is relevant, however it is too costly and time consuming to perform all the requested tests.
- It will be feasible only when automated testing methods will be implemented.
- It is relevant, however there are already established methods to exchange information with plastic recyclers regarding plastic flakes quality.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

currently, there are no standard quality criteria for PCR plastics, the required material performances are today mostly agreed on a case-by-case basis between the WEEE pre-processor. A short list of PCR properties to be tested and standards to be adopted can facilitate international communication between recyclers and OEMs and can make ease the identification of PCR for a broad variety of injection moulding and extrusion applications

Q.8. Performed analyses and surveys have demonstrated that PCR plastic requirements strongly depend on the targeted application. However, gathering inputs from researchers, OEMs and recyclers, a shortlist of uniform requirements to which PCR grades should minimally comply have been compiled. Making available the results of this list of tests will facilitate OEMs evaluating the applicability of compounded plastic granulates. To the greatest extent possible a program of hierarchical testing using existing standards is envisioned which will help define the final grades of recycled content material. In your opinion:

Available and requested

Colour	Aesthetical	ISO 11664
Tensile stress at Break	Mechanical	ISO 527-2/50
Tensile Strain at Yield	Mechanical	ISO 527-2/50
Tensile Strain at Break	Mechanical	ISO 527-2/50
Flexural Modulus (23°C)	Mechanical	ISO 178
Tensile Modulus (23°C)	Mechanical	ISO 527-2/1
Tensile Strength (23°C)	Mechanical	ISO 527-2/50
Charpy Unnotched (23°C)	Mechanical	ISO 179-1eU
Charpy Notched (23°C)	Mechanical	ISO 179-1eA
Density	Physical	ISO 1183
Melt Flow Rate	Rheological	ISO 1133
Vicat Softening Point	Thermal	ISO 306/A50
Heat Deflection Temperature	Thermal	ISO 75
Shrinkage at Production	Dimensional stability	ISO 294-4
Flammability Rating	Flammability	UL94HB
RoHS Compliant	Safety	201165EU
REACH Compliance	Safety	

Requested by multiple companies

Gloss	Aesthetical	ISO 2813,
Tensile stress at yield	Mechanical	ISO 527-2
UL registered	Others	
Filler content	Purity and chemical properties	ISO 3541-4
Food contact approval	Safety	EC 10/2011

Considered relevant by research

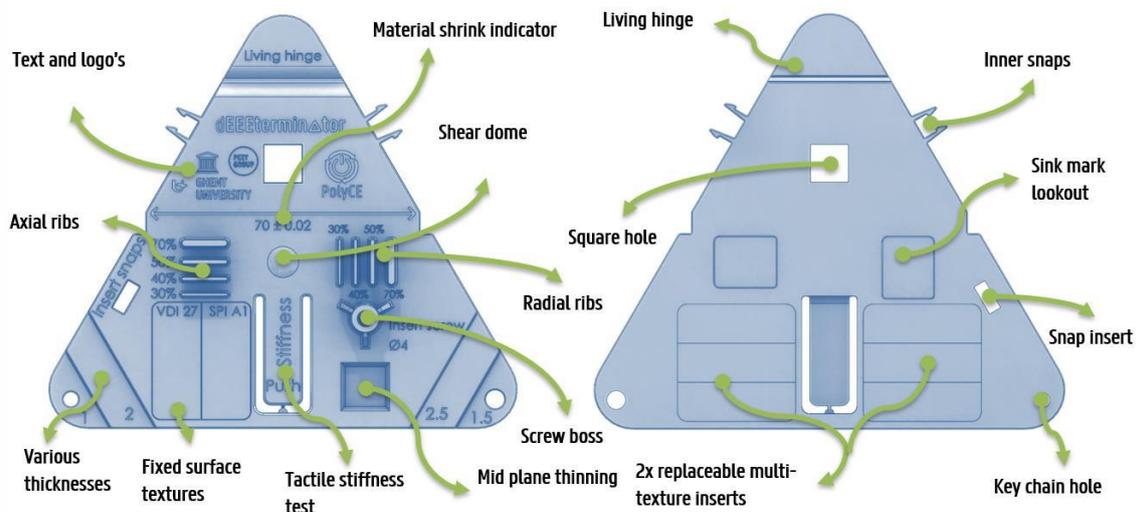
Recycled Content	History	EN 15343
Transparency in preparation and testing	Specimen preparation	ISO 19069, ISO 19062, ISO 2580, ISO 19063, ISO 7391, ISO 293, ISO 20753, ISO 294

- It is relevant, however it is too costly and time consuming to perform all the requested tests.
- It is relevant, however to perform the test required a standard containing the sampling methodology should be also developed. Moreover the tests should be repeated often due to the high variability of the input materials.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE findings, manufacturers are reluctant to use new, unknown materials and technical data sheets are an inadequate tool to convince manufactures to use recycled material in their products. The presence of high quality PCR recycled plastics is often thought of as non-existent: product designers should be introduced to these materials and their potentiality.

Q.9. Strategic tools have been developed to facilitate the effective incorporation of recycled WEEE plastics into high quality new EEE products. A “dEEeterminator” (a tactile hands-on injection moulding product; a design tools equipped with several materials evaluating and common EEE-product features, as the one presented in the image) and demo products (e.g. simple card holder, its high quality finish and functionality lend it perfectly for an convincing first impression.) should be produced as tools to promote the recycled materials and display their relevant properties, bridging the gap between a dry and scientific technical datasheet and the actual “feel” of the material. In your opinion:



- It is relevant, however recyclers need support to develop such kinds of tools.
- It is relevant, however, beside the technical datasheet, recyclers have already established methodologies to show materials properties to designers.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE outcomes, PCR plastics originating from the WEEE stream do not always meet requirements. To avoid the use of virgin material, it's worth exploring PIR plastics or other product waste streams (ELV, packaging, furniture).

Q.10. To increase the use of recycled plastic, synergies should be created among different sources of material (e.g. PCR and PIR plastics or plastics from different waste streams. In your opinion:

- It is relevant, however the amount of material collected and recycled is still too low to ensure a stable supply in terms of quantities and quality.
- It is relevant, however without an online platform it's very hard to find new opportunities and create synergies between stakeholders of different value chains.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to the PolyCE findings, there is a lack of communication between manufacturers (buyers) and plastic recyclers (sellers) and between recyclers and WEEE treatment operators. This lack of communication makes it difficult to find the rights partners and to create a long-term business relationship representing one of the barriers for PCR WEEE plastic uptake.

Q.11. An online comprehensive marketplace for PCR WEEE plastic should be established because it would help stabilize the material price and ensure constant material quality. The online marketplace should contain for each material put on the market a technical specification sheet reporting information on: material specification (quick identification of necessary material properties), material availability (long term availability is today a barrier), material (score system) and supplier reliability (reputational information). In your opinion:

- It is relevant, however the online marketplace should just be a tool to obtain information regarding PCR plastics not to buy them. Commercial managers should trade relations.
- It is relevant, however without guaranteeing a stable supply, the platform couldn't be a relevant tool for enhancing the use of PCR plastics.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.

- Great idea!

State of the art:

designers are key actors to promote products' sustainability and they have different options to do so.

Q.12. According to PolyCE findings, introducing modularity in design could reduce the overall discard of products thanks to the replacement of the damaged parts and could be beneficial for recycling as parts can easily break apart during the shredding phase. In your opinion:

- It is relevant, however it will be beneficial only if a considerable amount of manufacturers would adopt this strategy.
- It is relevant, however there are technical and economic barriers to implement this recommendation and there is a strategy feasible only for specific products.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE findings, a typical plastic fraction consists of a large variety of other polymers and impurities making it challenging to separate them by means of cost-effective technologies available. The presence of a large variety of polymers for example affects PCR plastics quality.

Q.13. A priority plastics guide for non-FR plastics to be used by designers of electrical and electronic equipment at the conception stage, can facilitate plastics recycling at the product's end of life. In the table are summarized the main guideline categories on avoidance of toxics (hazardous substances and components) and material purification as well as less material variety (polymers and non-hazardous additives). In your opinion:

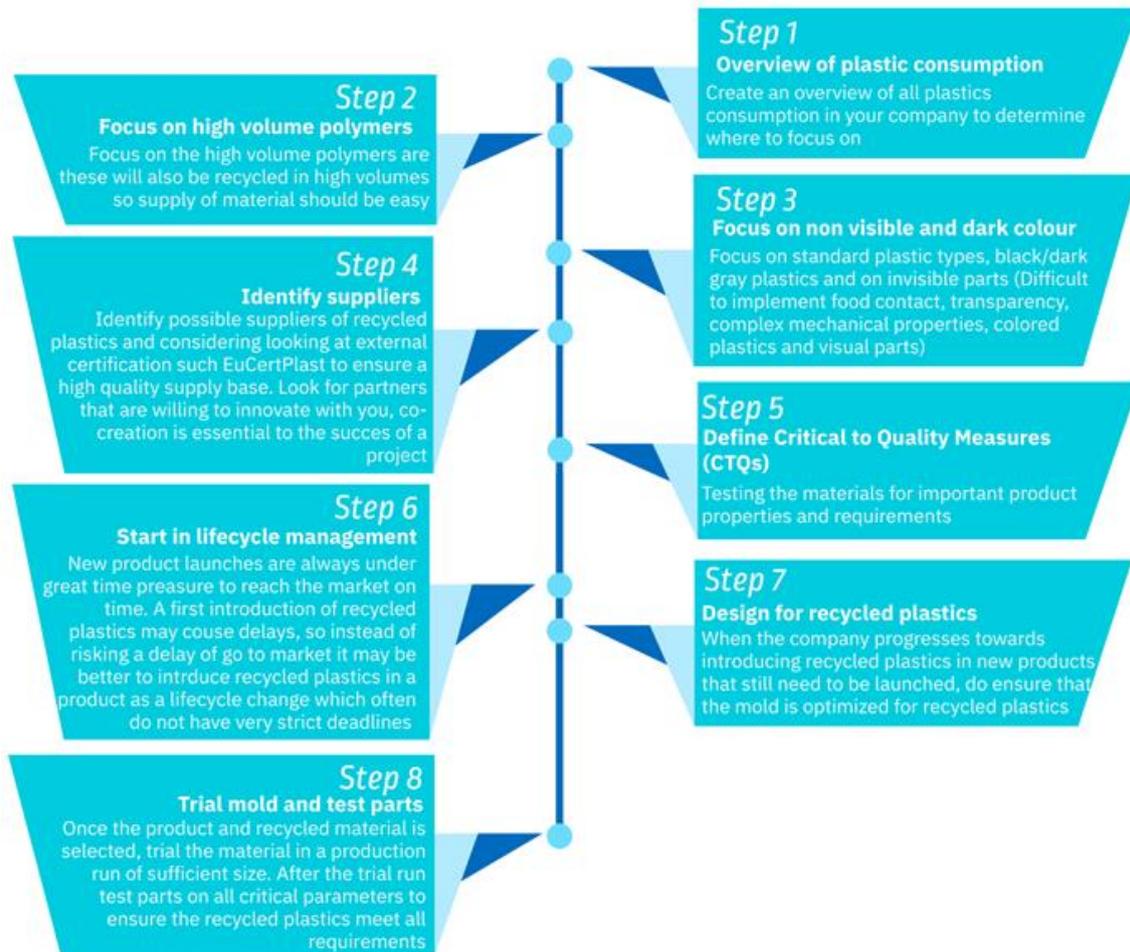
Hazardous substances and components	Polymers and non-hazardous additives
<ul style="list-style-type: none"> Do not use substances of very high concern (SVHC) according to REACH and no substances classified carcinogenic (Carc. 1A or 1B), mutagenic (Muta 1A or 1), reprotoxic (Repr. 1A or 1B) by CLP Regulation in housing/housing parts. Do not use any substances that are listed in the CARACAL list (Competent Authorities for REACH and Classification and Labelling) in the product. Concentrate hazardous components to one module / a restricted location to facilitate manual removal. When fixing hazardous or polluting components (e.g. batteries) in a product, use easily detachable solutions (e.g. click/snap) instead of permanent fixing such as adhesives. 	<ul style="list-style-type: none"> Use only common and easily recyclable plastics (ABS, PC, PC/ABS, PP, HIPS, PA). Do not use thermosets. If thermosets are necessary they should have another density than the common plastics used. Do not use elastomers. If elastomers are necessary, they should have another density than the common plastics used. Do not use halogenated polymers (e.g. PVC, PTFE). Do not use heavy metal based lubricants and plasticisers. Do not use Polyoxymethylene (POM). Do not use silicone compounds, oils or greases. Do not use montanic acid ester. Avoid coatings (painting, lacquering, plating, galvanizing) Do not use glass fibres or carbon fibres. If reinforcement is needed, prefer talc. Avoid moulding different plastic types together by 2K or xK processes. Use one single polymer in plastic casing parts > 100g. Avoid using connections that enclose a material permanently.

- It is relevant, however there are aesthetic and functional requirements that will make following these guidelines extremely difficult. Colour freedom/transparency/food contact grade is still a big challenge to use PCR plastic.
- It is relevant, however the indication regarding particular aspects of the product development, for example material choices, are made by OEMs and are closely related to economic evaluation.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

manufacturers can be reticent in implementing circular economy principles in their productions because they are afraid of failures and economic losses.

Q.14. Manufacturers should follow a 8 steps approach to successfully implement circular products. In your opinion:



- It is relevant, however this approach is strongly dependent on the target products.
- It is relevant, however reliability of the material quality and supply, as well as price stability and predictability compared to virgin plastic material are a major concern of OEMs.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE findings, there is a gap in the communication between manufacturers (buyers) and plastic recyclers (sellers). Manufacturers are reticent to use materials for which they have little ‘feeling’ for. Technical data sheets are typically not adequate to make a decision. It is tempting to fall back on previous knowledge and choose within a set of standard used materials.

Q.15. Strategic tools have been developed to facilitate the effective incorporation of recycled WEEE plastics into high quality new EEE products. A “dEEeterminator” and

demo products have been found to be useful tools useful to test the properties of the recycled plastics. In your opinion:

- It is relevant, however the stable supply in terms of quality is not guaranteed, therefore manufacturers cannot be sure that the properties presented through the “dEEEterminator” will stay stable along the time.
- It is relevant, however demo products should be produced in accordance with manufacturers’ technical requirements to be an effective tool.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

additives should not be considered just as potentially hazardous materials. The incorporation of additives in PCR WEEE plastic can improve the properties of materials and boost PCR WEEE plastic quality use.

Q.16. Manufacturers and compounders should closely collaborate: this would allow compounders to produce ad hoc materials to meet the specific manufacturers’ needs. Manufacturers should be available to indicate to compounders the key requirements for the target materials (e.g. colour, mechanical properties); compounders will set up process conditions consequently. In your opinion:

- It is relevant, however collaboration between manufactures and compounders is already well established, there are other relevant issues to be faced.
- It is relevant, however manufactures should be willing to accept some compromise in term of properties of the recycled material.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

State of the art:

according to PolyCE findings, the current WEEE/EEE plastic value chain is characterized by mistrust between actors and lack of data transparency. This makes it difficult to maintain the control on the quality of recycled material, it’s important to define quality tools to be used at every stage of the EEE/WEEE supply chain.

Q.17. The development of a quality management system is a key factor to increase data transparency, to structure and harmonize the communication in the plastics recycling supply chain and to support the trade and sales of PCR plastic. A uniform grading system for PCR plastics has been developed. In your opinion, the introduction of a grading system:

- It is relevant, however, there are already systems in place to control the quality of the PCR plastic along the entire value chain.
- It is relevant, however, to ensure a proper implementation at EU level, the system should be introduced in the legislation or in the existing European standards, such as the CENELEC one.
- It is not relevant, there are other more urgent issues that hinder the sustainability of the EEE/WEEE plastic.
- Great idea!

Annex II – The survey comments

8 STEPS APPROACH PER MANUFACTURERS

Companies should develop a decision **support tool that helps them evaluate the financial impacts** of using recycled plastics. Then a transparent decision can be made and design and product development has clear guidelines, under which conditions PCR plastic use should be evaluated

DESIGN GUIDELINES

- Guidelines should be hierarchical, i.e. a decision tree
- Two first points seem to be correct. I would add that sometimes OEM are more components buyer than a material specification specifier. They don't need to push for a material, they ask for a piece that meets the specification. In this case the plasturgist will do the choice of the material and the potential additive needed.

MODULARITY

Not sure if this is a sensible suggestion. Modularity is a corporate strategy that has much wider implications than plastics recyclability and has a very direct impact on profits

PCR PLASTIC MARKETPLACE

- I question if the platform can be built in a way that makes its business model sustainable. A registry of PCR WEEE producers might suffice and could possibly be run at much lower cost by an industry body
- You can ask at SKZ Wuerzburg, Germany. There are already planning sessions going on to establish such platform.

MINIMUM REQUIREMENTS AND TESTING

- It is relevant and with hierarchical testing costs can be kept low. However, at some point one has to ask what the effective difference between hierarchical testing and case-by-case agreement is.
- contents of substances of very high concern > 0,1 % w/w, contents of POP such as PFAS at 25 ppm
- EDX analytics should be contained, otherwise great idea!
- Providing this kind of information would be interesting. However, for the specification related to substances, this kind of datasheet should be more precise (give information

on the remaining quantity of some substances of concern) given that compliance with REACH for recycled material is something relatively complex to define

CLUSTERING STRATEGY

- I'm critical of this result. As your data and argument are not public on the website, I see no reason to change my view. Given the continued interaction with your project, I have the impression that "clustering" as a solution was already decided to be the solution in the projects conception and was not adequately evaluated.
- Treatment facilities: In practice, Treatment facilities should be authorized by each producer/importer of EEE. Then, pre-treatment needs to focus on extracting components that contain SVHC based on ECHA's SCiP data base.

INTRODUCTION OF CONSOLIDATION CENTRE

- The premise of this question is that the heterogeneity of more segmented collection streams is drastically reduced - I have not seen any data that convinces me that this is the case. In-device variability and In-segment variability is too high in many cases, unless a single-model tracking in the reverse logistics chain (including the necessary material composition data) is available.
- In France, we are already working according to this logic with mass consolidation points and sorting by flow before sending to dedicated recycling plants

CLUSTERED COLLECTION AT RETAILERS

- Drop-off needs to be as simple as possible as to enable high collection rate. It is not the duty of the customer to bring each device back to separate collection points!
- Involvement of retailers on a voluntary basis in order to be able to assess the added value of this material-based collection
- Doing this clustering can be a heavy workload especially when you manage an important quantity of waste (thousands of tons). Moreover, are we sure that same type of products means same recycling stakes related to materials or substances (maybe some coffee machines are made with plastics incorporating BFR and some not)?

CLUSTERED COLLECTION – THE ROLE OF CONSUMERS

- Collection should be based on logistics risks (battery, haz. material release) and costs of separation should not be pushed on the customer. Focus should be on reducing plastic use diversity in design.
- There should be regional clusters between virgin plastics producers, post-industrial recyclers, WEEE collectors, WEEE dismantlers, WEEE recyclers, and post-consumer recycling companies -- coupled with producers that use the recyclates, see German projects at SKZ Wuerzburg, <https://www.skz.de/de/forschung/veroeffentlichungen/7085.Veroeffentlichungen.htm>

THE OEMs ROLE

- The manufacturers are not ready since it is commonly believed that too much recyclates (> 10 % of the total) would weaken the product quality (esp. durability) of certain parts, components or of the housing.

dEEEterminator

Such cube already exists as produced by some plastics processing companies (injection molding, mostly). See Proto Labs Design Cube, <https://get.protolabs.co.uk/design-cube/>

GRADING SYSTEM

It would be important to harmonise the certification market.

PLASTIC FLAKES SIZE

In France most of the recycling plants already aim at supply plastic flakes around 10-20 mm and reduce dust from EEE waste (and in particular plastics) processing.