PolyCE

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

Project Duration:	**01/06/2017 - 31/05/2021**
Deliverable No.:	**7.5**
Deliverable Title:	Philips PCR plastics demonstrator
Version Number:	v1
Due Date for Deliverable:	**30/09/2020**
Actual Submission date:	**30/09/2020**
Lead Beneficiary:	**Philips PEN**
Lead Author:	Mark-Olof Dirksen

Deliverable Type: DEM

R = Document, report
DEM = Demonstrator, pilot, prototype, plan designs
DEC = Websites, patent filing, press & media actions, videos, etc.

Dissemination Level: PU

PU = Public
CO = Confidential, only for members of the consortium, including the Commission Services

Lead Author Contact: Dirksen, Mark-Olof
mark.olof.dirksen@philips.com

Contributing Partners

Name: Thijs Feenstra	Partner: Pezy Group
Name: Joop Onnekink	Partner: Pezy Group
Name: Arthur Schwesig	Partner: MGG
Name: Andreas Wolk	Partner: Sitraplas
Name: Gianni Vyncke	Partner: Ghent University

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730308

Introduction

At Philips, stimulating the collection and recycling of electronic equipment and medical products is an imported goal. Flowing from this attitude and in line with the sustainability push from the EU (Green Deal), an internal sustainability policy to force development teams to use more recycled plastics was set up. Starting from 2000 tonne recycled plastic used today, Philips challenged themselves and pledged to use 7600 tonne recycled plastics by 2025 depending on some pre-cautions. Philips's products contain only maximum 500 grams of commodity plastics, the rest being metal key components, thermoset plastics, food contact[1] or medical approved products[2] and electronics like batteries, LED's and PCB boards. Next to this, different products and part requirements need to be verified by proper testing[3] and validation method which takes time. Knowing these facts they have set quite the challenge for themselves.

This commitment to sustainable manufacturing is backed by the consumers. In the past years it has become clear that sales of consumer goods from brands with a demonstrated commitment to sustainability have grown with higher percentage compared to brands revoking it. As a result of the climate change and poor living conditions around the globe, many consumers have adopted more sustainable behaviours and now they also expect that corporations will take action. So when it comes to purchasing, they are doing their homework by checking labels, looking at web sites for information on business and manufacturing practice and paying attention to public opinion on specific brands in the news or on social media. Data from 2017 on consumer trends in Germany shows that more than 50% of consumers are trying to have positive impact on the environment and about 30% feel good by buying eco-or ethically- conscious products. Millennials display a strong preference towards switching to companies that are more ethical, as 9 out of 10 surveyed said they would switch to a brand that aligns with their values. This trend is being continued by Gen Z, as they show less brand loyalty. This is a powerful implication that will shape the business landscape to come as Gen Z will shortly become the largest consumer.

In this document we picture development and production results without revealing confidential application knowledge[4].

Task description

The main goal of this task is to bring together the knowledge gained from previous work packages into multiple large-scale demonstrators for the effective re-use of PCR plastics from WEEE and resulting in several individual products being developed with recycled WEEE plastics. This work aims to develop demonstrators where PCR plastics are used in consumer lifestyle components or in entire products. Demonstrators within this product group, which contain recycled polymers already exist, but use polymers of non-WEEE origins. Philips is committed to go one step further and to develop a consumer lifestyle component, based on PCR plastics from WEEE, thus effectively closing the loop. The choice of material and component will be made based on the results of the PCR plastics analysis performed in other work within PolyCE and the Design-from-Recycling strategy (WP2). Next to this, demonstrators where PCR plastics are intended to replace the currently used primary plastics will be developed with existing PCR material grade. The demonstrator is designed to cover numerous stages of the supply chain, encompassing product design, reverse logistics, collection and recycling.

Within the PolyCE project Philips also aimed to develop new insights gained from tangible demonstrator prototypes and test the limits and possibilities of recycled plastics. The demonstrators are developed by applying the Design from Recycling approach and looking at the three key pillars for development: Drop-in complexity tool, Six step material approval and Look&Learn. These pillars formulate the base of the Drop-in Method as described in these guidelines.

[1] FDA, EU, China, fatty food, etc.
[2] Class 1, 2a, 2b and 3
[3] Philips General Test Specification (application tests relevant to the product) and safety & compliance schemes
[4] specific design rules, manufacturing parameters and a detailed way of working

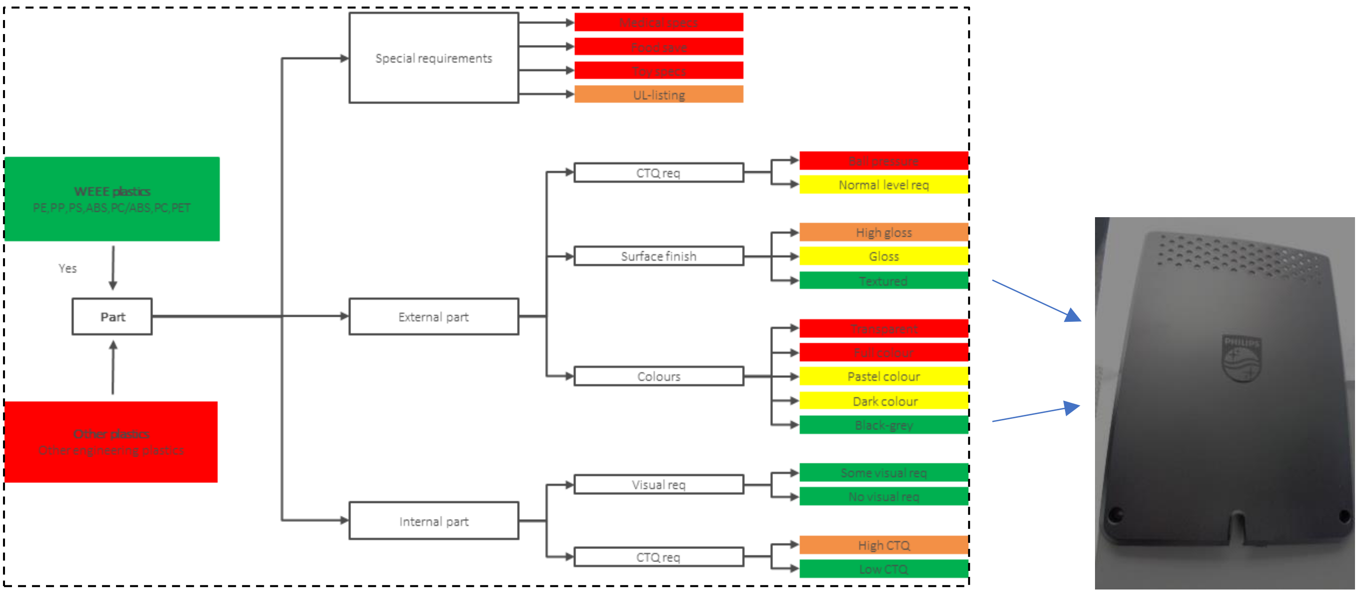
Approach

Complexity level matrix

Selecting which part or product to target is the first important step to be made when starting implementing recycled materials. How to approach the selection stage can be difficult as all products and parts have different requirements. To aid in selecting a part/product that is most likely to succeed, a complexity level matrix[5] (CLM) was developed in cooperation with Pezy. Note that this tool is developed to select products suited for a drop-in strategy (tooling exists). The tool can be found below and uses a colour code and a decision structure to identify how "easy" the implementation of recycled plastics in a specific part/product would be. Green is easy to implement and equals a low risk because of low part/application requirements and red is very difficult to implement (or impossible due of legislation) and equals high risk because of stringent part/application requirements.

As an example we will look at the expresso machine side panels as a possible candidate part. We start on the left side of the CLM, here the first selection is made based on the used material. Using commodity polymers[6] ensures a recycled grade will be available as not all types of polymers are targeted by recyclers. In the case of the espresso side panels, ABS is used and so a green light is given on this first selection. The next selection, is based on the characteristics of the parts, ranked from easy (bottom) to hard (top). Here internal parts impose less difficulties as these usually only fulfil functional requirements. External parts are more difficult as these require a certain esthetical quality. Under special requirements we find medical specs, food contact parts, toy specs and UL-listing. Here legislation imposes the biggest hurdle. At the time of writing we do not yet recommend starting up cases which require food contact for EEE products. Looking back to the example, this is an external application where the parts are textured and black. A green success rate is obtained so the chances for success are rather high.

By using the CLM it is possible to identify the "low hanging fruit". This will increase the chances of success and knowledge gain. Resulting in a portfolio of successful cases/products and building up confidence before moving to more challenging products/parts.
Based on this internal complexity level matrix, parts, validations and risks were planned/estimated.

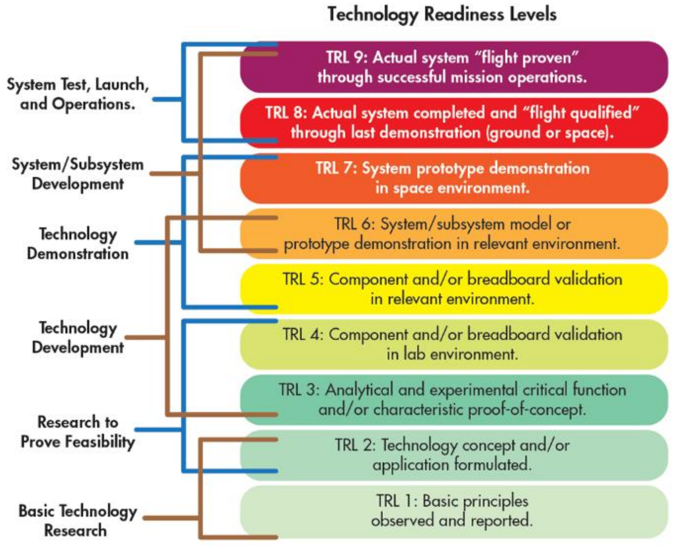


[5] More information in the design for and from recycling: practical guidelines for designers
[6] For EEE sector: PE, PP, (HI)PS, PC, ABS, PC/ABS, PET

Technology readiness level

The demonstrators of Philips are validated throughout the project duration of PolyCE up to a certain Technical Readiness Level (TRL). This ranking gives indication of how far companies are with product validations, and is commonly used in automotive and aerospace industry. In 2010 this ranking was also adopted by the European Commission for EU horizon 2020 research and innovation projects. Some ideas (e.g. brush heads) were only briefly explored, others became prototype parts (e.g. hairdryer), demonstrator products (e.g. vacuum cleaner), parts with full product release (e.g. shavers) and even commercialized products (e.g. SENSEO® Eco)

- TRL 1 – basic principles observed
- TRL 2 – technology concept formulated
- TRL 3 – experimental proof of concept
- TRL 4 – technology validated in lab
- TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified
- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies)



Material focus:

The focus on plastic use, at Philips Healthtech, is broad but specific for electronic household appliances[7]. An overview of materials, their main reason for use and the challenges regarding recycled grades of these materials is given in the table below.

Material (virgin)	***Main reason for use***	***Disadvantages recycled versions***	***Main improvement needed***
hPP	High gloss deep black, high HDT, food contact	Recycled smell, bad quality in WEEE stream, no high gloss	High gloss, purity (food contact not always needed)
cPP random	Impact resistance at 0 degrees	OK	Charpy notched at 0 > 5kJ/m2
cPP block	Transparency, food contact	Tinting, non-transparent	Availability transparent PP's
PP + 40% talc	Stiffness internal frames	Low E-modulus	E-modulus comparable to virgin ≈ 5GPa
PP + 30% GF	Stiffness internal frames	Bad recyclability in WEEE stream, rest ok	Not yet a target material
MABS	Transparent ABS parts, containers, better scratch, limited use	Mixed with the ABS fraction	Not targeted as a separate material
ABS	High impact, adhesion of TPU, high gloss, lacquering and plating options	Lower impact	Improve impact, deep black
PC	Heat stability, transparency	Impact loss! Tinting	Tinting
PC/ABS	Balance stiffness, processing and ESC	Risk of bromine, flame retardant versions	UL versions, non FR
HIPS	Alternative for ABS at light colours - no coffee staining	Impact, FR versions out	Colour versions, white goods
SAN	Transparency, water containers, food contact	Not available, less used	Other waste streams?
PA+20%-40% GF	Technical internal parts	Food contact for coffee machines	Price
coPET	Transparent parts, water containers, very ductile, glass look	Not available	/
PET-G	Packaging, thermoformed grades	Tinting, mainly PET-A	Make the PET mouldable

The main focus is put on the materials listed below, as these make up the largest amount of material use.

- High gloss deep black PP, preferably homopolymer PP or high impact copolymer PP
- High gloss, deep black ABS – possible to paint and perform 2K moulding
- PP + 40% talc for internal frames
- Matt colored HIPS
- Transparent PC
- Colour freedom in general

Next to this, it is also important to have insight on the material properties that are most valuable for converters. The following properties are considered as focal for new or existing recycled materials.

- Visual quality should be a priority and not the mechanical properties
- Purity, cost, smell and plastic aging investigations are research points for the plastic recyclers
- Most common recycled material problems faced by Philips are:
  - Documentation that can provided
    - Technical Data Sheets (TDS), MSDS, CoA, CoC
    - More comparison possibly between commercial grades
  - Application specifications
    - food contact, drop tests, climate test, life time ageing for 7 years
    - Thermal, chemical, moisture, UV ageing in relation to mechanical properties & fatigue and creep properties
    - Visual appearance – high gloss, colour, transparency, black spots
    - Smell & taste – food/drink appliances

[7] conform NEN-EN-IEC 60335-1:2012/A12:2017 regulation, without UL listing

    - Processing – again smell, settings & stability, degradation, contamination of moulds

- Most recycled materials tested in the last 8 years at Philips were rejected by the high requirements set by Philips.

Results

Summary of demonstrators in different businesses

Business Home Care (Vacuum cleaners, bag and bagless)

The vacuum cleaner demonstrator included the moulding and product validations of 13 different recycled ABS parts. Results for all parts tested with WEEE sourced ABS grades of MGG polymers were positive. Requirements per part differ but most important properties for all parts are impact (drop test), climate tests, aesthetics (high gloss black) and fatigue. During moulding of the wheels a small asymmetry was noted. Root cause could be mould shrinkage in combination with suboptimal moulding parameters and is being worked out. As Philips was already using recycled PP in this product, it was possible to make a fully functional bagless vacuum cleaner from WEEE recycled plastic (>75% recycled plastics). A demo was given at the 2019 consortium meeting.

Business Coffee (Senseo, Espresso)

The Senseo and Espresso machine (side panels) moulding trials and product validation showed positive results for applications of WEEE sourced ABS grades from MGG polymers and PIR PC from Sitraplas. For these products ball pressure tests and aesthetical quality of the high gloss visual housing parts are the main properties. More important is a certain colour freedom. Together with Sitraplas, the team developed beautiful colours in: PolyCE green, nougat brown, diffuse white, deep black and smokey translucent black recycled PC. The cooperation with MGG polymers proved the possibility of delivering a super high gloss deep piano black rABS for large housing parts without compromising on PCR content (100% recycled). With the Senseo Eco Philips won the European PRE recycling award 2020 and is commercially available for retail.

Business Male Grooming (Shavers)

The shaver demonstrator showed that moulding and product validations of inner frames of shavers have positive results for the use of WEEE sourced PC/ABS grades of MGG polymers. This functional part is used in millions of Philips products produced in Europe and China. The part has challenging requirements mainly on dimensional stability, water tightens (IP67), impact and chemical resistance (against lotions). In total 4 batches are taken in production for full release tests, results are largely positive. However, a worse chemical resistance of the recycled grade versus the virgin grade causing some cracks in the adapter plug inlet was noted. New design rules are needed to decrease the force and tolerances of this module. Secondly, a minor difference in mould shrinkage was observed, which is higher for recycled materials. A need to either adapt the CpK window or optimise moulding parameters to increase size part after moulding and before assembly is suggested. It is expected to implement the recycled inner bodies with new design rules in 2020/2021.

Other businesses (Beauty - hairdryers, OHC - brush heads)

Next to the abovementioned demonstrators Philips PEN (TEG) uses test moulds to execute and plan pre-development work and generate concepts for other Philips businesses. Some of these products are included in the work of PolyCE and discussed in more detail in the following sections. This way of working leads to deeper knowledge on pre-cautions, design restrictions and opportunities for new circular product propositions. In cooperation with Pezy, Philips developed a training for Design for and from recycling, these slide decks are publicly available.

Results of the Philips demonstrators

Vacuum cleaner

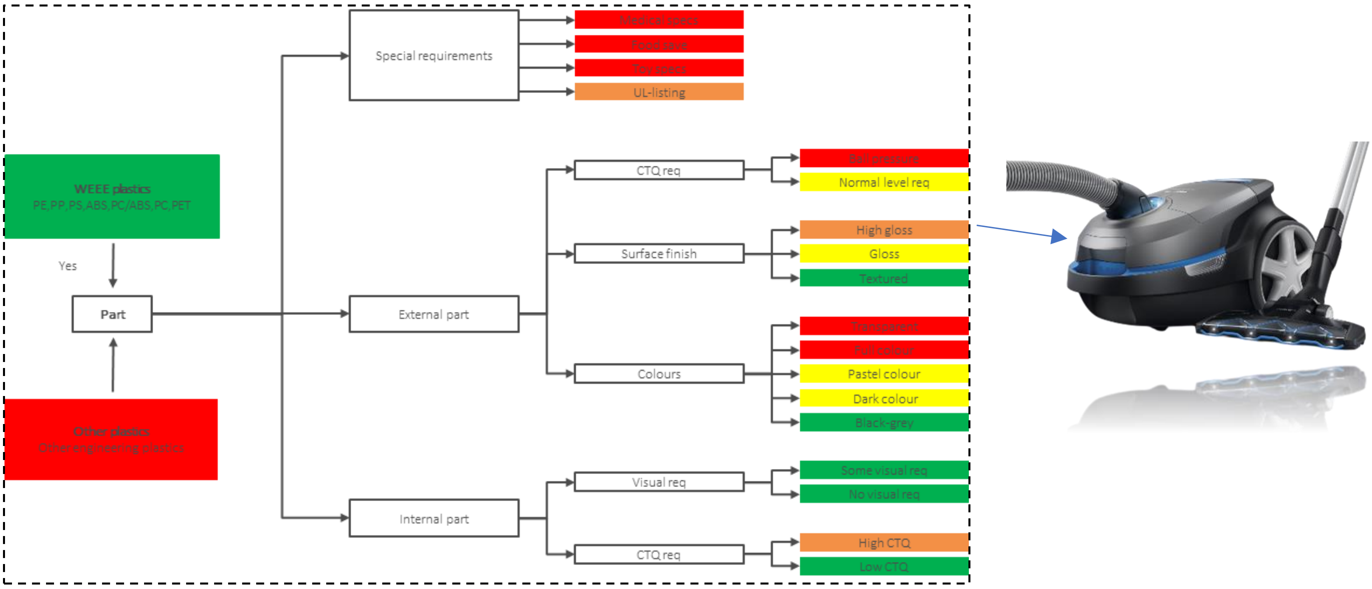
Short case discussion: The application of WEEE-sourced PCR ABS in different vacuum cleaner parts including high gloss visual parts is possible with no design changes. The biggest difference with virgin ABS is the process optimization (compensate mould shrinkage, flatness of round parts, lower melt temperatures needed). The demonstrator will be used internally for input of different new product launches in the future.

One of the most striking demonstrator cases is the floorcare demonstrator using 100% post-consumer recycled ABS sourced from Waste of Electronic and Electrical Equipment (WEEE) in two demonstrator models. From the standard high-gloss black version to the premium lacquered, both models contain, overall 75% recycled plastics. The products are both functional and passed all safety and quality test without any compromises. With these products a new benchmark has been set for the market. The quality of some recycled plastics today is very high, and in some cases even outperforming aesthetical expectations as is proven in the high gloss black vacuum cleaner demonstrator. Knowing that only 1% of all EEE products on the market contain recycled materials, efforts like these prove that there is an alternative way. The demonstrator replaced 13 parts in the vacuum cleaner using both materials from within the PolyCE (MGG polymers) and the CloseWEEE (Sitraplas) project. The most important properties of these products are impact (drop test), climate tests, aesthetics (high gloss black) and fatigue. During moulding trials a slight asymmetry of the wheels was observed. The root cause of this issue is being investigated but could most likely be mould shrinkage in combination with suboptimal moulding parameters. The product contains the following materials per major components.

- PP lower housing
- ABS buttons (on/off, cord set)
- 2K ABS wheels (TPU overmoulded)
- ABS (spray-painted) housings (dustcover)

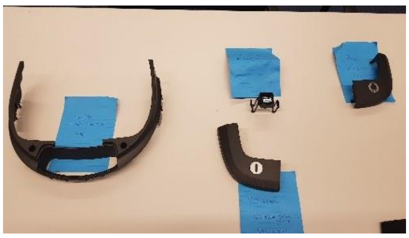
Prior to full scale moulding trials the material was test-moulded on prototype parts. The results of the lacquering tests (discussed later) were used for this demonstrator.

CLM result:



TRL result:

Nr	Demonstrator name	Product / Part / Material / Process	TRL	CTQ 1	CTQ 2	Next steps
7.6 A	Vacuum cleaner	2K wheels	7	Paintability	Dimension tolerances - ovality	Process DOE on asymmetricity
		On/off buttons	8	Dimension tolerances	Droptest	Fit for application
		Deco rims	8	Dimension tolerances	Droptest	Fit for application
		Top cover	7	Homogenous surface finishing / Gloss	Dimension tolerances - ovality	Fit for application
		Small buttons	8	Homogenous surface finishing / Gloss	Functional - fatique	Fit for application



Coffee Machine

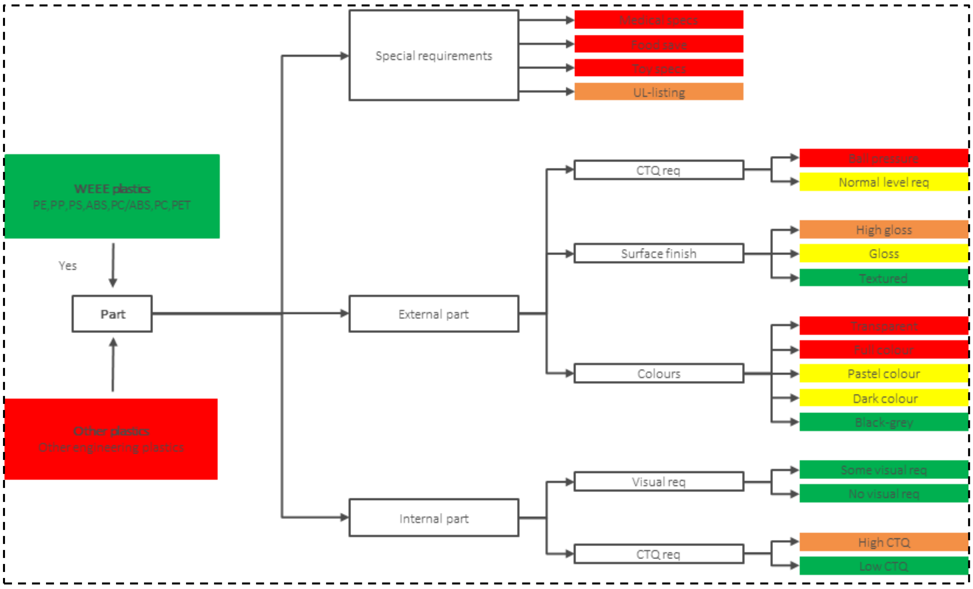
Short case discussion: The application of PCR ABS and PIR PC in different coffee machine parts including high gloss (Senseo) and textured visual parts (Espresso) is possible without design changes. Floorcare parts were used as input for this business case (cross category learnings). A big advantage of PIR PC is the colour freedom needed for these type of consumer products. Combining a newly developed colour (PIR PC, nougat) with large area tampon printing for the top parts resulted in a commercial launch of the Senseo Eco range.

The greatest success of a demonstrator case resulted in a commercial launch of the Senseo Eco. SENSEO® is a complementary partnership between Philips and Jacobs Douwe Egberts, where Philips plays a key role in developing the appliances roadmap. As part of Philips's Eco Design and Green products strategy, combined with the ambition to make the complete SENSEO® coffee system more circular and sustainable, the introduction of the Viva Café Eco model in 2020 is the next important step and development towards a more circular economy. From the start, the Viva Café Eco appliance has been designed to be the most sustainable coffee machine yet. A previous attempt to introduce an Eco machine included exclusive recycled materials that could not be replicated for mass production. With the new Viva Café Eco this hurdle was eliminated. It marks a new starting point where Philips released high quality, visual recycled materials in all outer parts of the appliance. Additionally, the machine's energy consumption has been reduced and the packaging materials have been optimized, all contributing to an overall reduced environmental footprint. Besides increasing the recycled material content in this product, the team involved designed a special 'speckle' effect that does not impact the plastics' recyclability but does provide a new aesthetic that matches the consumers' environmental awareness. The look of imperfection and the random effect on the material creates a sense of desirability, the lack of a mass production feeling and looks more natural. SENSEO® is one of the most sold single serve coffee systems in Western European and Nordics countries. This allows SENSEO® to have a big impact on consumers; raising their awareness around circularity and engaging them in adopting sustainable behaviors. At SENSEO® we believe that consumers shouldn't have to choose between good tasting coffee and the environment. Philips is therefore committed to continue this journey in innovating for sustainability. This is our first big step in a long-term program towards more circular solutions.

The speckle effect is influenced by the design trend of displaying natural looks. Philips has rightfully added a similar, sustainability message on the coffee machine. There are more and more products appearing in the market with speckled surfaces, showing consumers a new aesthetic that feels more in line with their footprint awareness. Material imperfection creates desirability and unique pieces. Imperfect and random effects look more natural, and therefore more emotional.
In Viva Cafe Eco project, Philips managed to develop an in-depth, good looking speckle effect with special printing techniques, without impacting the recyclability of the material. This was achieved by using a tampon printing technique that keeps coating levels well under the 1% threshold, recommended for recycling.

The end result is a Senseo Eco Viva café coffee machine with recycled plastics content of 75% (not including Food contact material parts). In this case a combination of both PIR and PCR materials were used to overcome certain hurdles like for example colour freedom.

CLM result:



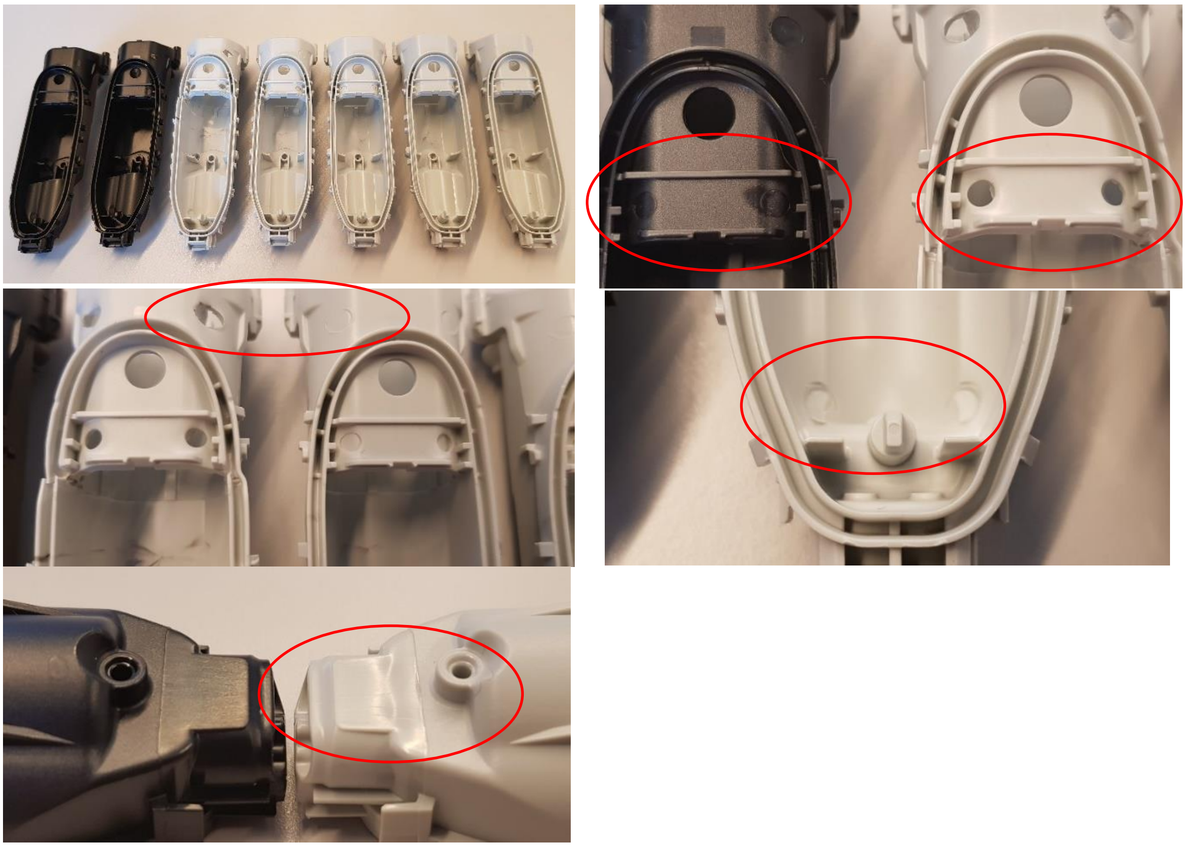
TRL result:

Nr	Demonstrator name	Product / Part / Material / Process	TRL	CTQ 1	CTQ 2	Next steps
7.6 B	Senseo	Lid cover	9	Full colour freedom	Climate testing - discoloration	Fit for application
7.6 C		Lever	9	Full colour freedom	Fatigue (open/close)	Fit for application
7.6 D		Housing	9	Homogenous surface finishing / Gloss	Drop test	Fit for application
7.6 E		Front cover	9	Homogenous surface finishing / Gloss	Ball pressure	Fit for application
7.6 F		Lid	9	Homogenous surface finishing / Gloss	Drop test	Fit for application
7.6 G		Baseplate	9	Homogenous surface finishing / Gloss	Impact	Fit for application
7.6 H		Buttons	9	Homogenous surface finishing / Gloss	Printability	Fit for application

Shaver

Short case discussion: It Is found that the application of PCR PC/ABS in shaver inner frames is not possible without design changes. All application tests were positive except for ESC tests on body lotions. This chemical test is very specific to these products. Design rules related to the power plug connection (part of the frame) are redeveloped in order to accommodate the lower ESC resistance of PCR PC/ABS. Expectation is to implement the recycled inner bodies and the new design rules in 2021.

In this demonstrator case two materials are tested, a black PCR PC/ABS and light grey PIR PC/ABS. Moulding and product validations of the inner frames of shavers showed positive results for applications of WEEE PC/ABS grades of MGG polymers. This functional product uses about 130 T of PC/ABS each year, which would mean a big step towards the pledge of 7500 T by 2025. This part has severe property requirements on dimensional stability, water tightens (IP67), impact and chemical resistance (against lotions). The material is taken in production for full release tests, results show to be mainly positive. In the pictures below the issues and differences between both materials are highlighted.



Several issues came up when performing moulding trials with the light gray PIR PC/ABS grade. The main issues are listed below.

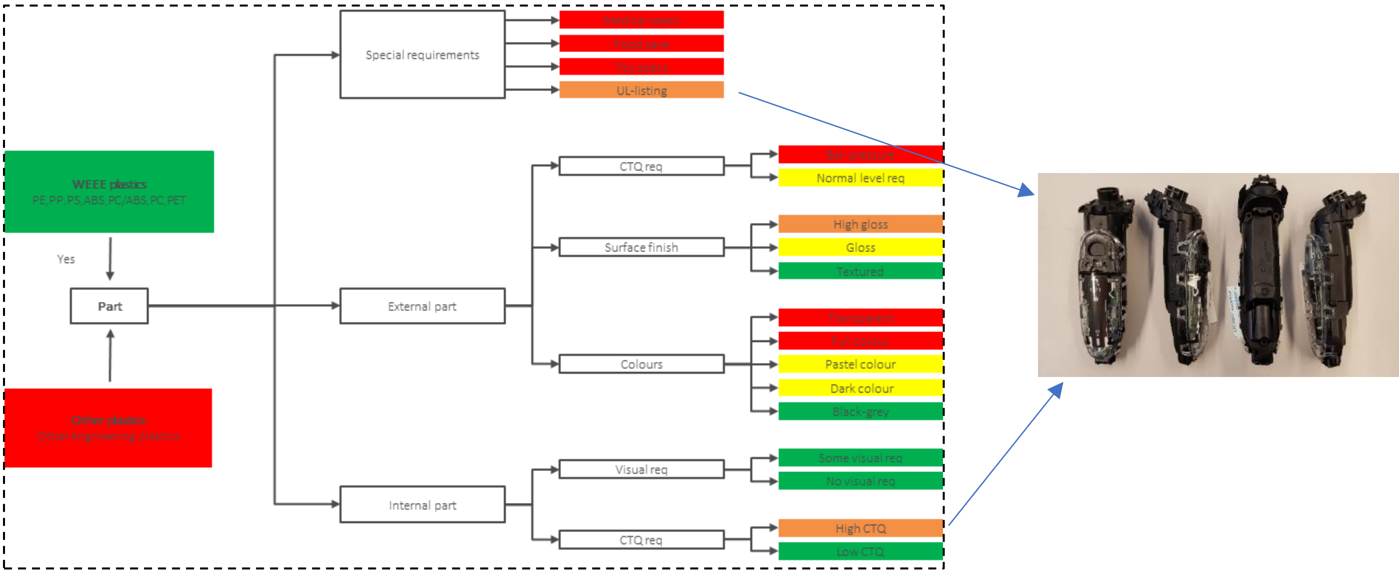
- Ejector pins deformation of inner frames (also puncture)

- Decrease melt temperature with 20 degrees
- Cavity filling variations
- Unstable process
- Dimensions out of spec
- Brittle parts once cooled
- No assembly was found possible

Regarding the black PCR PC/ABS the trials were mainly successful. Moulding trials, dimensional tolerances and assembly tests all showed positive. Other release test required all passed except for ESC resistance. This issue will require more effort to sort out. The lower ESC resistance cause cracks in the adapter plug inlet, which compromises the watertightness of the product. New design rules are needed to decrease the force and tolerances of this module. On top of this a minor difference in mould shrinkage was observed, where the one of the recycled plastic is a slightly higher than of the virgin grade resulting in smaller parts and possibly leading to in a crack in the screw bosses. A need to either adapt the CpK window or to optimise moulding parameters to increase size part after moulding is suggested.

Crack (resolved)

CLM result:



TRL result:

Nr	Demonstrator name	Product / Part / Material / Process	TRL	CTQ 1	CTQ 2	Next steps
7.6 I	Basic body	Inner frame	7	Droptest	Water tightness/dimensional stability	Fit for application

Parts and test mouldings:

As mentioned before, Philips PEN (TEG) uses test moulds to execute and plan pre-development work and generate concepts for other Philips businesses. This way of working leads to deeper knowledge on pre-cautions, design restrictions and opportunities for new circular product propositions. Some of these product are included in the work of PolyCE and discussed below. The sections are compromised of what the goal and outcome of the trial is, the requirements for success and the knowledge gained.

Lacquering trials of rABS

Functional Release Testing finishing applications

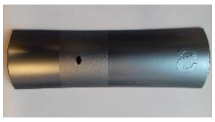
Lacquering test were performed on recycled ABS test parts to research the possibilities of two new developments. A: single layer lacquers and B: lacquering of body parts from recycled plastics. Both trials proved successful and are demonstrated on large scale in the floorcare demonstrator.

Requirements: Good bonding of spray paint with WEEE sourced recycled ABS (Evosource grade ABS4535), a single & thin layer, metal/aluminum look (for high-end products only)

- Plastic: MGG polymers, Evosource grade ABS4535
- Lacquers: Schaepman - http://www.schaepman.nl/

Knowledge gain:

- Density change because of the spray paint remains lower than 1%. Measurements are based on (large parts) m/m % weight before and after spray-painting (excluding volume increase)
- Release tests for applications in coffee-R&G & floorcare all passed. Performed tests are listed below
  - Dry abrasion (Taber test)
  - Cleanability (n-hexane)
  - Adhesion test (cross hatch)


- Two colors were released:
  - Silver
  - Silver blue
- Because of the black plastic base, deep scratches are clearly visible (compromise of quality)

Moulding recycled PC: exploring in-mould colour options.

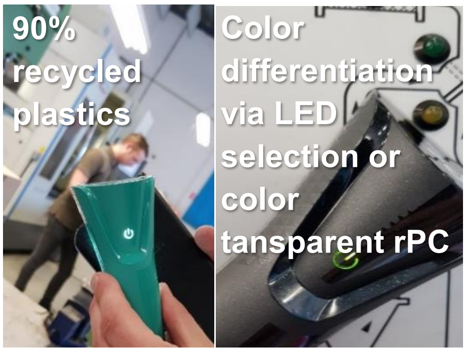
Moulding trials on a 2K shaver demo part were performed with recycled PC grades to gain knowledge on the possibilities of in mould colouring and user interface integration. Test showed to be successful and was used as input for on-off buttons of e.g. Senseo coffee machines.

Requirements: Show recycled PC options with 2K molding (test tool of a shaver). The material used is a post-industrial recycled PC.

- Supplier: Sitraplas
- Grades: SITRALON EP11762 / C6600 (green), SITRALON EP11762 / C01745 (smokey black)

Knowledge gain:

- Based on the TDS information the Charpy impact of rPC is very low
- Moulding of both grades is OK
- The recycled PIR PC is clean and contains no visual contaminations of particles. Gloss is excellent.
- Smell; not observed
- With the transparent recycled PC designers can play with:
  - User interfaces (UI) integration (led icons, 2K, light guides & diffusion)
  - Masking of smoked black over a colour (depth & differentiation)
  - Two colour moulding
- Improved light experience
- Adding functionality to recycled plastic
- Tested in Senseo light ring (integrated in Coffee machine demonstrator)
- Fully recyclable concept (PC/ABS). Discussed with recyclers during consortium meeting.



Dust covers colours

Test parts were moulded using colour sorted recycled ABS from MGG polymers' pilot trial. Results showed that the colour sorted ABS (red and blue) is of excellent quality. The tests showcase a next step toward colour freedom in PCR plastics. Economic feasibility studies to upscale production for these materials are being performed to roll out colour sorted materials in the future.

Other

Next to the above mentioned cases, other smaller cases were set up and. These are briefly mentioned below.

- Hairdryer (low wattage) body

  Short case discussion: The application of PCR ABS in high wattage hairdryers is not possible because of IEC safety regulation in relation to the current designs. All application tests were positive except for ball pressure tests at Dekra (test institute). Status is that the business can only use PCR ABS for low wattage products and beside the black colour, pastel colours are needed. Project is at this moment on hold for PCR ABS.

- Espresso machine side panels (parallel to development of Senseo Eco

  Fit for application

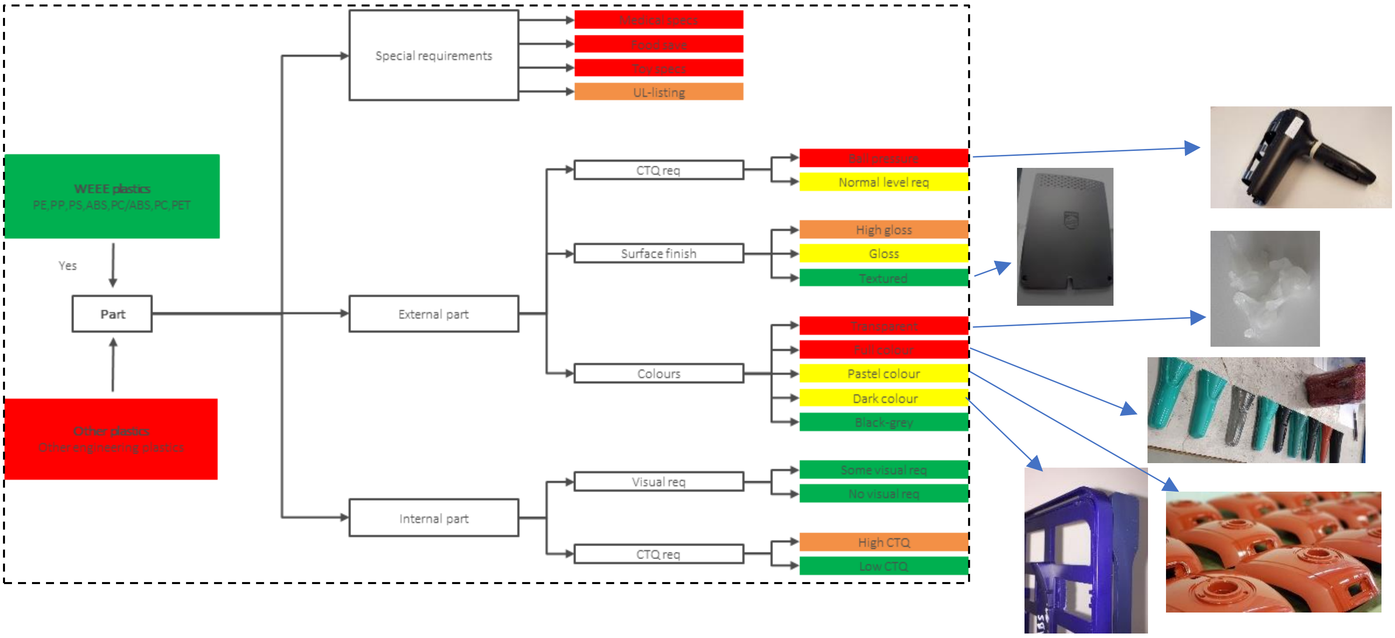
- Oral healthcare (OHC)

  Our medical OHC business is also interested in a risks and possibility evaluation of food contact approved recycled plastics in brush heads (BH). Collection of BH's in WEEE is assessed because of the RFID tags which will be implemented in the future. Application of PCR plastics in food or medical products is not yet possible because the 95% clean origin waste source cannot be guaranteed and identification of additives in the polymer is not possible (medical traceability needed for Class 1 products). Chemical recycling of physical recycling is the technology Philips will develop for these businesses.

- Espresso machine inner frames

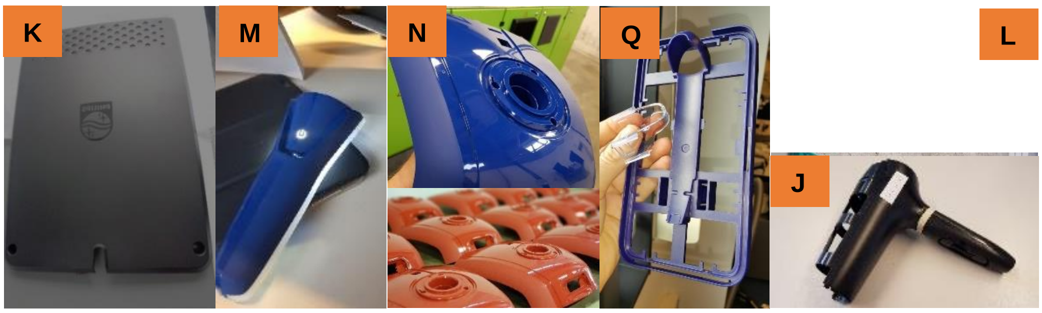
  Further optimization needed

CLM result:



TRL result:

Nr	Demonstrator name	Product / Part / Material / Process	TRL	CTQ 1	CTQ 2	Next steps
7.6 J	Beauty hairdryer	Housing parts	7	Ball pressure	Homogenous surface finishing / Gloss	Fit for application – only low wattage
7.6 K	Espresso machine	Housing parts	8	Flowability moulding	Homogenous surface finishing	Fit for application
7.6 L	Shaver 2K – colour options	Test mould	4	Recyclability	Full colour freedom	Full colour freedom in PCR, volumes/price
7.6 M	Shaver/Senseo diffuser	Light-guide – test mould	4	Added value – diffuse light	Transparency/smokey black	Costs of 2K process
7.6 N	Vacuum Cleaner colours	Dustcovers	5	Colour – Gloss – surface quality	Mouldability	Stop – availability – production volumes recycler
7.6 O	Oral Healthcare	Brush head + handle	2	Collection scheme	Food contact approvals	New case May 2020
7.6 P	Espresso Inner frames	PP talc	8	E-modulus	Price	Improve E-modulus with cost effective talc
7.6 Q	One Blade	Santorini blue frame	8	Colour match with virgin ABS	Stiffness	Moulding test in Romania



Conclusion & learnings

In conclusion it can be said that the Philips demonstrator task was a great success. Many successful cases and a lot of knowledge was gained from the efforts put into this task. When linking the demonstrator to the complexity matrix we can see that many red (high risk for implementation) and orange (medium risk for implementation) fields are successfully tested in prototype production. The PolyCE project opened many opportunities which were not possible with only a Marketing/Customer demand. Biggest advantage is the speed and continuous focus on the implementation of recycled plastic instead “from project-2-project learnings”.

Most important learnings across the many recycled part validations and discussions around Circular Economy business cases related to the executing of Philips projects within the PolyCE project:

1. Key work points on material level Drop test failure, chemical resistance, materials shrinkage and plastic strength in relation to part designs (brittleness) are risks for implementation.
2. IEC requirement ball pressure can lead to rABS part failures when > 90 degrees Celsius.
3. Color and gloss requirements of Philips are high (delta E<1). Also deep black is a color.
4. Mold pollution in time can add business case costs (more frequent cleaning).
5. Positive trend is that the odor (perception) of recycled plastics are improving.
6. Philips is open to change to sustainable materials under DfX cost-down scenarios. This is understandable as the drop-in approach will not gain quality improvements and/or added functionality (which is in the part and product design) rather then
7. More validation efforts & costs.
8. Business risks like RoHS and REACH safety are always relevant. Recyclers need to promote more Q-batch testing and in-line SPC data when available.
9. Financial compensation (tax benefits at sales point, recycled material refund at procurement stage or a virgin plastics tax) of companies using PCR plastics to generate positive business cases in high volume low margin consumer goods will change the playing field. As for our market not all consumers/countries are asking for recycled plastics.
10. Quality of recycled plastics out of WEEE have been improved over the last (project) years and the current black rABS grades with combined gloss levels and properties are close to virgin ABS. Next step is color freedom by compounding, color sorting in-line or to develop chemical or physical recycling technologies.
11. Material UL listing is needed for plastics used in products sold in the US. The associated costs for the UL Yellow Card tests are normally too expensive for the volume’s recyclers produce. We also learned that recyclers need to deliver more lots compared to registration of virgin plastics which increases the costs at the manufacturing site even more. Leveling the playing field in the future is needed.
12. It takes many years for business to make the shift from virgin plastics to recycled plastics. Each product and part needs to be validated in line with our IEC filling.
13. Biggest organizational leaning: The PolyCE project opened many opportunities which were not possible with only a Marketing/Customer demand. Advantage of such project is the speed and continuous focus on the implementation of recycled plastic instead “from project-2-project learning”.
14. In general, we can conclude that recycled styrenics (ABS, PC/ABC) from PCR source and PC from PIR source are implementable in EE products with minor design changes. When requirements like chemical resistance for PC/ABS parts (in our cause against lotions), impact resistance related to hPP’s and ball pressure requirements for ABS parts are getting strict, lowering the recycling content is the only options. The experience is that many recyclers are not willing to do that in their recycling/compounding facility. Cooperation with virgin plastic recyclers to start developments in the area of compounding with virgin, physical and/or chemical recycling can overcome these problems even for applications in the food contact products and products in the medical field.

In general, we can conclude that recycled styrenics (ABS, PC/ABC) from PCR source and PC from PIR source are implementable in new EE products with minor design changes. When requirements like chemical resistance for PC/ABS parts (in our cause against lotions), impact resistance for cPP's and ball pressure requirements for ABS parts are getting strict, lowering the recycling content is the only options. The experience of Philips is that many recyclers are not willing to use virgin plastics in their recycling/compounding facility. Cooperation with virgin plastic recyclers to start developments in the area of compounding with virgin, physical and chemical recycling can overcome these problems even for applications in the food contact and medical field.

The demonstrator case contributed to various objectives (listed below) of the PolyCE project. All product cases contributed to objectives 1 to 6. The Senseo Eco contributed a great deal to points 1,2 and 5. It can also be stated that the Philips cases indirectly influenced an increase in employment (green jobs) by investing in the use of recycled materials.

1. O1:Develop and test circular business models for an enhanced plastic circular economy
2. O3:Enabling and strengthening the market of WEEE postconsumer plastics
3. O4: Re-design the recycled plastics supply and value chain through establishing the most effective methods for reverse logistics, product clustering and supply chain management for improved collection, sorting and reprocessing
4. O5: Decrease the environmental footprint related to virgin plastics and improper EoL treatment of WEEE plastics (incineration and landfill)
5. O6: Maximise awareness through information and promotion of the PolyCE results

Indirectly effecting:

6. O2: Build Strategic Collaboration Network between all key actors within the plastics value chain and establish Dialogue mechanism between them
7. O7: Increase employment and create green jobs

As a final conclusion it can be said that the knowledge gained and the work related to the demonstrators and the spin-off to Philips production is positive. The PolyCE project resulted in many kick-offs and CE proposals to innovation & development, design and marketing.