PolyCE

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

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Lead Beneficiary: **Pezy**

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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

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Contributing Partners

Name:	Partner:
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Gianni Vyncke	Ghent University
Andreas Wolk	Sitraplas
Gunther Höggler	MGG polymers

Disclaimer

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Summary

Pezy set out to design and produce an EE product in cooperation with an SME partner. Together with Wireless Value, a SME producing wireless sensors, a new product housing line was developed. During the development process of these products, Design for/from Recycling guidelines were closely followed without compromising on quality and functionality. Only one case formed a problem where functionality required the use of a waterproof seal. Even here various options were considered and the option with the least amount of impact was selected. Next to this minor incompliancy, the products fully comply to the used guidelines and prove that the use of recycled materials (both PCR and PIR) can result in a functional and eye-pleasing end product. In the end a successful market release with positive feedback from the consumers proved that the use of recycled materials can results in a sustainable, profitable and desirable product.

Task description

"In this task Pezy developed with one of its SME customers a new demonstrator product within this side of the market (e.g. household appliance), based on PCR plastics from WEEE, defined as suitable for Design from Recycling in WP2."

Composing the assignment
A cooperation with Wireless Value has been launched. The company, Wireless Value, is a 'design center' for wireless products. In addition to the development and production of wireless measuring and control systems, they deploy their expertise for a wide range of wireless products, making various applications in various markets ranging from hospitals, the agribusiness, heavy industry and the consumer at home. Over the years, they created many housings for different purposes, resulting in a product portfolio that exists of numerous housings that have different shapes, colours and materials.

A uniform design language was desired into a product line that represents the brand. Future products must be recognizable as a Wireless Value product and reflect the core values of the company. At the same time, this offers the opportunity to think about a modular platform of products with which it is possible, for example, to put together various architectures (products) with a number of "basic blocks" that meet different requirements.

Wireless Value requested Pezy Group to support them in this challenge and to find a suitable approach together.

Goals

Create an electrical consumer product for an SME, made from Post-Consumer Recycled (PCR) plastics and designed to be optimally recycled and that needs to be:

- Technically feasible
- Usable and attractive by its user
- Profitable for the SME (business case).

Approach

Creating these housings by following the complete product development process from idea till production. This includes the implementation of the Design for Recycling guidelines, using PCR plastics, recognizing hurdles along the way and eliminating them as good as possible. The delivery of the demonstrators serves as proof of what TRL level can be reached. Hurdles that cannot be removed or evaded will be visible and give direction for future research.

At the start of the development process, several aspects concerning the requirements of this product in combination with design for / from Recycling were indicated that needed to be investigated:

- Options of PCR plastics
    - Colour options/limitations
- Design for shredding: no tapes, glues or other permanent fixings
- Specific requirements: RF transmission shielding of PCR plastics unknown
- Logo on product

Options of PCR plastics:

Creating a circular product means the materials used in the product will be recycled and re-used in new products at its end-of-life. To make a design that completely serves the goal of circularity means to implement Design for Recycling and start thinking about Design from Recycling.

Our starting point was the current housing, that was made of ABS plastic with a wall thickness of 2.5 mm.

Current housing

Step 1: Sourcing for PCR ABS started.
MGG delivers EvoSource™ ABS 4535. Technical data sheet looked promising to fit with requirements.

Step 2: small scale testing of the material with existing moulds to check processing and product behaviour, including aesthetics.

Testing material with existing moulds

Step 3: Check options for colour freedom, to be able to communicate different categories/sensor configurations. 4 different colours were selected. Next to white:

PMS	PANTONE 375 U	PMS	PANTONE 1797 U	PMS	PANTONE P Process Cyan C
CMYK	41, 0, 78, 0	CMYK	0, 99, 100, 4	CMYK	100, 0, 0, 0
RGB	160, 206, 103	RGB	227, 27, 35	RGB	0, 158, 224
	#a0ce67		#e31b23		#00a5e3

Colour options/limitations

To know the possibilities for obtaining coloured materials (ABS) need for our purposes, two partners within the PolyCE consortium were consulted, MGG polymers and Sitraplas. Below, the possibilities found for commercially available coloured PCR, PIR and virgin ABS are listed[1].

[1] The results listed were obtained only consulting MGG polymers and Sitraplas at the time of the project. The recycling industry keeps improving and expanding their material portfolio, please check with multiple recyclers what possibilities are currently available

1. Most preferred stream: Post-Consumer Recycled (PCR) from MGG polymers:
    - Colour: ABS with limited colour options. Deep and bright colours not (yet) possible.
    - Availability: Black (deep black) is commercially available in low volumes.
    - Price: less or comparable to virgin.
2. Secondly preferred stream: Post-Industrial Recycled (PIR) from Sitraplas:
    - Colour: ABS available in natural. To be coloured by compounding. Full freedom of colour. Masterbatch colouring is difficult.
    - Availability: Commercially limited availability, low volumes.
    - Price: Higher than virgin
3. Virgin plastics from regular suppliers:
    - Colour: Full freedom in types of plastics and colour.
    - Availability and price: Low volumes possible by using masterbatch as colouring technique.
    -

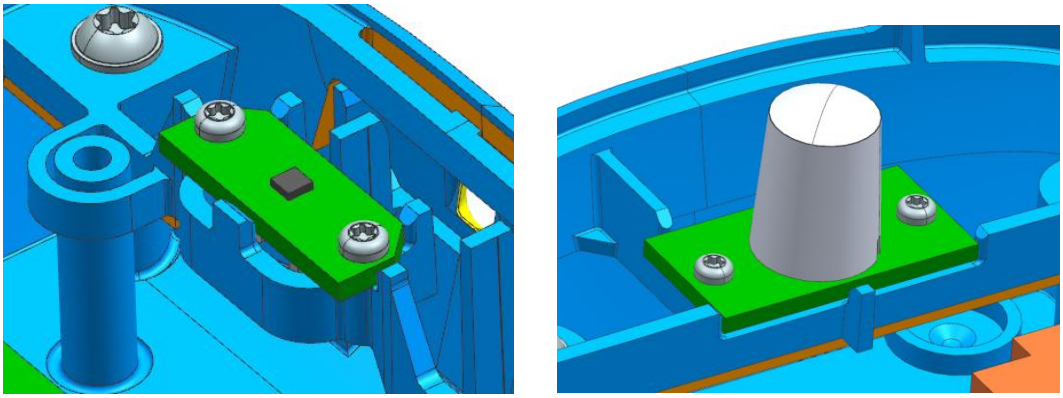
Choice: PIR and virgin are the only technically feasible options. From an economical perspective virgin is the best option. This is due to the fact that with PIR coloured material, a necessary compounding step is required, this drives up the cost, especially in low volumes. Below, a comparison is shown between the virgin and PIR materials. As can be seen, from an technical and optical perspective no difference can be found.

Colour comparison between PIR and virgin

Design for Shredding

Design for Shredding is part of Design for Recycling, thinking about the techniques used to recycle allows to design a product that will have a minimal of loses during recycling. One of the most common techniques used in WEEE recycling is shredding, this breaks up the product in smaller pieces and in the best case separates the different material component. This is not always easy to accomplish. Some products e.g. cell phones are a glued together. During shredding the product will not fall apart in the different material components, which makes it harder to recycle or it can even end up in residue and be incinerated. Some design points taken into account in this demonstrator regarding Design for Shredding are listed below.

- No glue or tapes. Only screws
- No different materials moulded together or materials permanently enclosed



Internal parts like PCB's have been fixated to the housing with screws

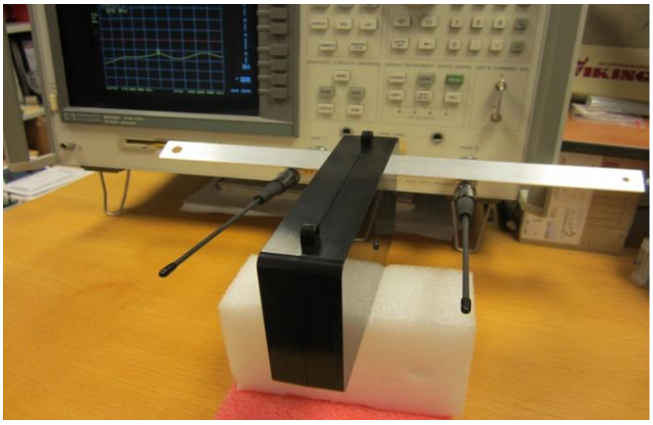
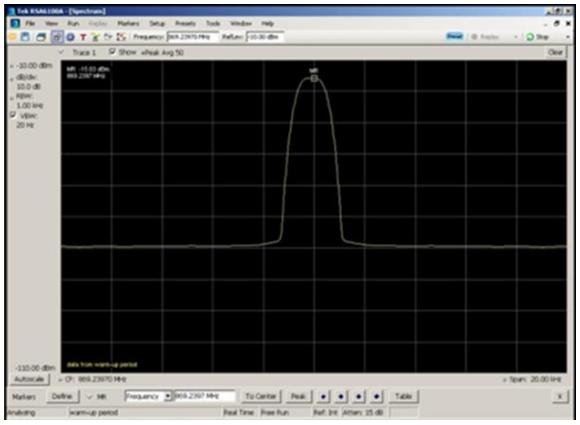
Specific requirements

The black colour in PCR materials is mainly caused by a high content of carbon, frequently used as a colouring pigment. Carbon could cause interference on radio signal, used to transmit the data collected by the sensors. To ensure no problems would occur for this application testing is required. Pezy built a prototype mould to produce a housing with a comparable wall thickness as the existing (and intended) housing of Wireless Value.

By producing the prototype housings in a selection different materials, the effect on signal strength/transmission could be investigated.

Materials tested:

- Terluran GP-22 uncoloured (Common virgin ABS grade)
- Terluran GP-22 coloured black (Common virgin coloured ABS grade)
- MGG ABS Evosource 4535 (Intended ABS PCR grade)

Conclusion:
The results show no difference in signal strength. It can be concluded that the carbon content in PCR materials will not significantly affect the radio frequency (RF) transmission. However, it must be made clear that this is only true for this specific application with a certain wall thickness, material and RF signal. No conclusions can be made for applications with deviant parameters.

Branding with logo

To show the manufacturer of the product, adding a logo to the product is common practice. However, adding a logo can be done in numerous ways, of which not all are optimal for recycling. For this application two choices were possible for a logo on the housing, in-mould or a tampon printed logo.

Tampon print:

- Design for recycling: Low amount of lacquer added to ABS cover. Amount is much lower than 1%. Therefore not disrupting the recycle process.
- Design: Colour freedom and small details possible.
- Price: Extra production step needed per product. > € 1,-

In-mould:

- Design for Recycling: No lacquer added. Best option from a recycling point of view.
- Design: No colour and limited detailing possible in this case.
- Price: Part of production of texture in tooling.

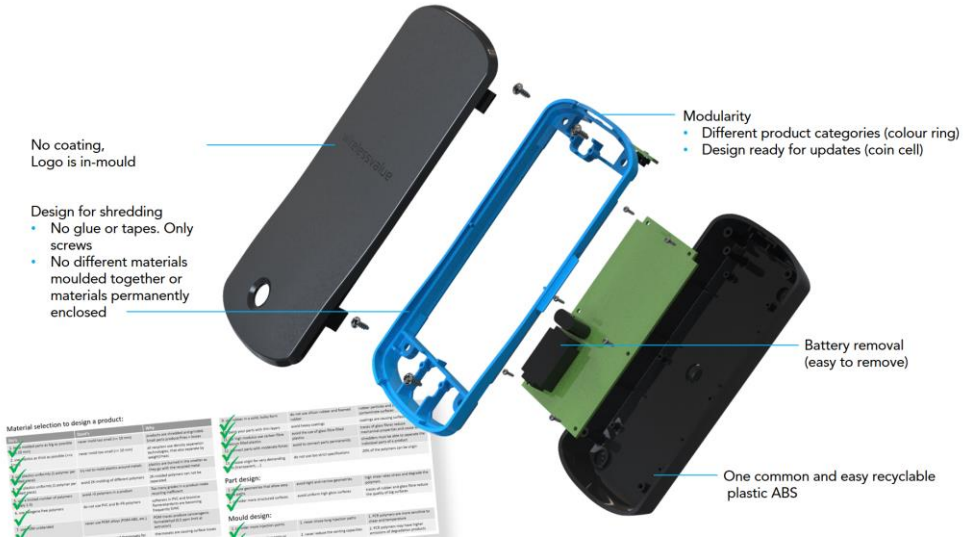
Both options comply to the design for recycling guidelines. The choice can be made on aesthetical basis and price, although no lacquer will keep the recycle stream more pure. After discussion with the SME partner an in-mould logo was chosen.

Results

We started by reducing the number of different housings needed to cover all possible applications. The result is a product family of 3 housings, a small, medium and large version that, together provide the new platform for wireless measurements in all needed varieties. The small and medium housings were developed as final products to showcase the challenges and possibilities across the complete development process.

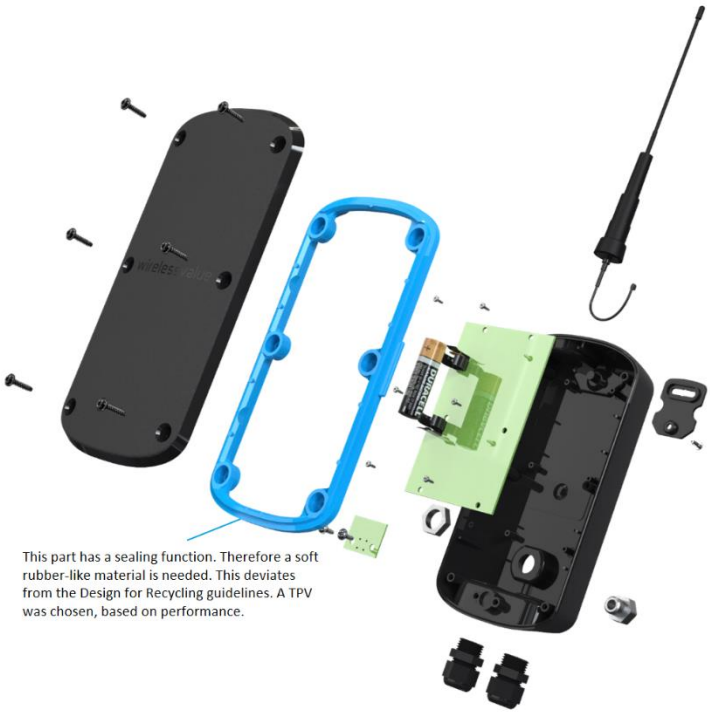
Design for Recycling

Making a design that is based upon the Design for Recycling guidelines gave the designers a technical puzzle that, by making fundamental decision in the concept phase, resulted in a housing that is fully recyclable for the WiSensys Small housing.



The small housing meets all guidelines, and is therefore optimally recyclable.

To fulfill all the technical requirements for the WiSensys Medium housing, one of the parts had to be made in a material that is currently not being recycled. Since this housing needs to be watertight, the ring part needed to be made from an thermoplastic elastomer, to provide a water sealing function. Since elastomers are currently not recycled and it is advised to avoid the use of elastomers, alternatives were explored. The outcome resulted into uncertainties in the functionality or an overall worse score regarding Design for Recycling. Therefore the choice was made based on performance and a TPV was chosen. It is unknown to what extent this will affect other recycle streams. However in discussion with the recyclers within the consortium these seem to be removed quite efferently. The choice was made to mould the seal individually instead of 2K moulding, this will ensure that during shredding the TPV seal will separate from the other materials, making recycling easier.



Design from recycling

All parts, except for the coloured ring, are made from Post-Consumer Recycled plastics (ABS). For the WiSensys S version, the ring was made from Post Industrial Recycled plastic (ABS), to provide full freedom in colour options. However this was only possible within the scope of the project. The additional costs regarding the use of PIR could provide issues in the future. For the WiSensys M version, a coloured TPV was chosen, this material is only available as a virgin feedstock for now.

The level of mechanical and aesthetical quality of the parts are not distinguishable from virgin.

The medium housing meets all requirements, except for the seal, to fulfil all necessary technical requirements

Conclusion

WiSensys S housing

- Design for Recycling: By making the correct choices, we were able to create a design that meets all the requirements and guidelines from WP 2. These plastic parts of the WiSensys S can be fully recycled.
- Design from Recycling: The bottom and top are made from PCR plastics. The aesthetics of the parts are on par with virgin plastics.
- Obtaining colour freedom from post-consumer recycled plastics is limited. However, recyclers make it a work point to improve upon soon. Regarding colour freedom PIR materials can offer an alternative to virgin material. Both PIR and virgin plastics are feasible options from a technological perspective.
- From an economical perspective virgin is the best option, especially in case of low volumes. The idea that recycled polymers are inherently cheaper than virgin is something that comes as natural to many of use. However, this is not quite logical knowing the processes needed to produce the material. However, in most cases recycled will still be cheaper than virgin. In specific cases like for example, colour matching PIR will be more expensive due to the need for specialty compounding steps compared to masterbatch colouring.

WiSensys M housing

- Design for Recycling: The bottom and top part are, similar to the S parts, made from PCR plastics. The ring part has a sealing function. Therefore a soft rubber-like material is needed. This deviates from the WP2 design guidelines:
- Ring is made from TPV. Choice of TPV is based on performance (sealing function), and not on Design for/from Recycling point of view, as no information is (yet) available.

- Design from Recycling: No TPE with the needed low hardness found on the market. Full colour options are needed.

Define your CTQ's and do in house testing. Speciality properties can be tested with test moulds, e.g. RF shielding.

Start sourcing materials early this will help with making smart decisions based upon what is known or even unknown about the material.

Look out for any specific hurdles that are not applicable when using virgin plastics:

- Material availability (does a recycled grade exist, Tons/year, Long term supply)
- Material quality consistency
- Functional requirements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