Interreg North-West Europe
TRANSFORM-CE
European Regional Development Fund

Business support – case study Reflower

Redesigning products with recycled plastic feedstock

Business support – case study Reflower

Redesigning products with recycled plastic feedstock

As part of the TRANSFORM-CE project, several case studies will be done to assess the conditions that foster the uptake of recycled plastic feedstock in (new) products. This document covers the results of the case study at Reflower, based in the Netherlands. A total of 20 case studies will be done, each representing one product to be (re)designed with recycled plastic. In depth support will be given to five cases per country (The Netherlands, Germany, Belgium and the United Kingdom).

Date 14 February 2023

Authors Karla Münzel, Malou van der Vegt, Joris van Tubergen

Deliverable
WPT3 D3.4 Redesigned products with AM
WPT3 D3.5 Redesigned products with IEM
WPT3 D3.7 Redefining Circular Economy business models

This research has been conducted as part of the TRANSFORM-CE project. The Interreg North West Europe support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Programme cannot be held responsible for any use which may be made of the information contained therein. More information about the project can be found on: **www.nweurope.eu/transform-ce**. TRANSFORM-CE is supported by the Interreg North West Europe programme as part of the European Regional Development Fund (ERDF).

Table of contents

1. Introduction and method

1.1 Goal of case study

TRANSFORM-CE is an international research project about the uptake of recycled single use plastic (SUP) feedstock. A core part of this project is to provide in-depth business support to businesses willing to use recycled plastic materials in (new) products. The uptake of SUPs implies that companies in the plastic industry must make a major transformation. In order to gain a better understanding of the support required for the wider uptake of recycled plastics (such as SUP) by companies, 20 different case studies will be completed, documenting the conditions that foster the uptake of recycled feedstock. In line with the technologies of the pilot plants from the TRANSFORM-CE project, cases will represent either IEM[1] technology or AM[2] technology.

Thus, the aim of these case studies is twofold; 1) to support the case study company with their specific request to help foster the uptake of recycled plastic feedstock into one of the company's products, and 2) to gather insights into the conditions necessary to support the wider uptake of recycled plastics by using IEM and AM technologies. The case studies also present a unique opportunity to study the technical requirements for (re)designing products with IEM and AM. The learnings of the various cases and (re)designed products could serve as a proof of concept that provides the entire value chain with the insight and confidence to uptake recycled feedstock, creating circular economy opportunities for all stakeholders.

1.2 Case study process

The case studies are being carried out between September 2021 and December 2022. The case study process is structured in four steps[3], with an iterative approach at the end of each step. The first step (*initial diagnostic*) aims to establish a starting point and describes the challenge to be addressed. The second step (*circular product development*) captures basic information about the product (re)design and describes prototyping and testing leveraging IEM and/or AM technologies. The third step (*circular product management*) covers how to commercialise the new (or redesigned) product and describes the product's relevance for business and environment, creating a successful circular business model. The last step involves a wrap-up of the results and concludes with strengths of the redefined business model, an overview of the barriers and enablers for circularity, and learned lessons from the case study. The final result is a case study report, covering the previously established information.

---

[1] IEM: Intrusion-Extrusion Moulding (for low(er) value recycled material), a combination of two techniques to produce plastic products/components. With extrusion the polymer is being melted, thereafter the polymer is being forced into a shape (by using a mould).

[2] AM: Additive Manufacturing (for high(er) value recycled material), method of creating objects layer by layer according to a digital design.

[3] This work uses insights derived from other activities of TRANSFORM-CE, in particular the case study method of WPT3 D2.1: *Case study methodology - Researching good practices of circular economy business models.*

The total case study can be seen as a package of business support (all steps). Yet, a specific type of 'in-depth support', chosen from the menu-card[4], will be done for each case study. This support differs from company to company and will be selected based on a first analysis of the case. Examples of in-depth support include: material testing, prototyping and production trials, implementation of technology and use of recycled filament.
An overview of the case study analysis process is shown in figure 1 on the next page. In order to obtain the results, a 'collaborative/participative' assessment is used to collect further information, which gives insights in the overall innovation process. At the end of the case study, an iteration will be done to validate the results. The reported results will be send to the contact person by email, so this person can validate the results and check if something is still missing or if information has been misinterpreted. Any comments will be processed and the results will be adjusted accordingly. Table 1 gives an overview of the people that have been interviewed during the case study.

Table 1: Overview of interviewed people

Interviewed person	Function
Ellyne Bierman	Founder and owner of Reflower
Erwin Boxen	Founder Slimprint

[4] An extensive list of the support possibilities is presented in a separate document '*Transform-CE support Summary*', describing the menu-card.

Step 1. Initial Diagnostic

- First assessment of company
- Establish starting point
- Describe challenge to be addressed
- State project goal

Step 2. Circular Product Development

- Describe product to be (re)designed
- Assess context in which product will be produced, used and marketed
- Design product
- Describe product's relevance for business and environment
- Create successful circular business model
- Prototyping and testing leveraging IEM and/or AM technologies

Step 3. Conclusion

- Wrap-up of results
- Strengths of redefined business model
- Summarise barriers and enablers for circularity
- Describe learned lessons

Report

- Succinct, yet informative case study report
- Excellent exposure opportunities for business

Figure 1: *Overview of case study process*

2. Step 1 – Initial diagnostic

The first step focusses on an initial diagnostic of the case study, which includes outlining the company profile, its wishes and the project goal.

2.1 Company profile

Reflower is a start-up based in Amsterdam that supplies artificial flowers with a matching vase via its sustainable flower library on a subscription basis (Flowers As A Service, FaaS). The company does this on both a private and B2B basis. By making the switch from cut flowers to artificial flowers, a structural CO2 reduction is ensured and the company contributes to the circular economy, due to the fact that the artificial flowers are reused many times. The company provides customers with a bouquet of artificial flowers with a vase on a subscription basis. This subscription gives them the opportunity to choose a bouquet of artificial flowers with a vase that will be delivered by appointment. If the subscriber wants a different bouquet, it can easily be exchanged for another bouquet from the digital flower library.

A short overview of Reflower is given in table 2.

Table 2: Overview of company

Topic	Information
Company name	Reflower
Website	https://www.reflower.nl/
Country	The Netherlands
Size of company (0-10, 10-200, 200-500, 500+ employees)	0-10
Mission/vision	'Minder verse bloemen in laten vliegen en weggooien' 'Reduce, Re-use, Reflower'
Value proposition	Reflower rents out bouquets consisting of a vase with artificial flowers in a subscription form. Artificial flowers are durable and reusable and therefore contribute to a circular economy.
Main activity	Renting out and delivering bouquets of artificial flowers in a vase and exchanging bouquets on request.

2.2 Current situation & challenge

Reflower has already adopted a business model contributing to sustainability by using durable and reusable artificial flowers instead of cut flowers that are often transported by plane and by making use of a subscription form in which bouquets can be exchanged and reused once the customer wants a new bouquet. The artificial flowers are transported by ship to the Netherlands (instead of plane) and are transported to clients mostly via cargo bike. Brzesowsky et al. (2022) have calculated that a bouquet of Reflower emits less than 2 kg of CO_2 while a bouquet of floriculture flowers emits 3,5kg of CO_2.

Reflower wants to contribute even more to sustainability and increase the circularity of the business model. The vases used currently are mostly made of ceramic and break easily during

transport. This is not sustainable and financially not desirable. Also, Reflower has no clear view on the production process of the vases. Reflower is looking for vases that have higher durability (wear-resistant, impact-resistant) and a lower environmental impact. Additionally, Reflower is looking for a more sustainable flower arrangement solution (insert) that can be used in the vases to style the flowers. The current material used is not reusable and of an unsustainable material (oil).

"Flowers seem green because they are green, but it is not that sustainable at all"
- *Ellyne Bierman, Founder of Reflower*

Description of support

Transform-CE analyzed multiple types of vases (different materials and production processes) on 6 requirement factors as well as 3 goal dimensions (sustainability, efficiency, price). Three vase prototypes were built and tested them on a number of characteristics. One design was chosen as the best fit for the goals of Reflower. It is a vase 3D-printed of recycled material. The vase is drop and impact resistant, water-repellent and waterproof. The vase has a large neck opening so that the artificial flowers can be arranged in a good way. In addition, this vase is well within the budget of Reflower.

Furthermore, Transform-CE analyzed multiple types of flower arrangement inserts (different materials, mechanics and production processes) on 6 requirement factors and again 3 goal dimensions. 6 insert options were developed and analyzed on tested on a number of characteristics. One design was chosen as the best fit for the requirements. It is a PVC – tube containing a copper wire ball .

3. Step 2 – Circular product development

After creating a first analysis of the company and project, a more detailed assessment of the (re)designed product is made. This includes basic information about the product and an assessment of the context in which the product will be produced and used, as well as an analysis of the circularity of the product. Moreover, a more detailed design of the product is created, which goes hand in hand with prototyping & testing.

3.1 Circular product canvas

The new (or redesigned) product is investigated by using a circular product canvas (CPC). This model is created for the purpose of this study and covers the main aspects to consider in circular product design. The CPC of Reflower is visible in figure 2 and a description of each element is given below.

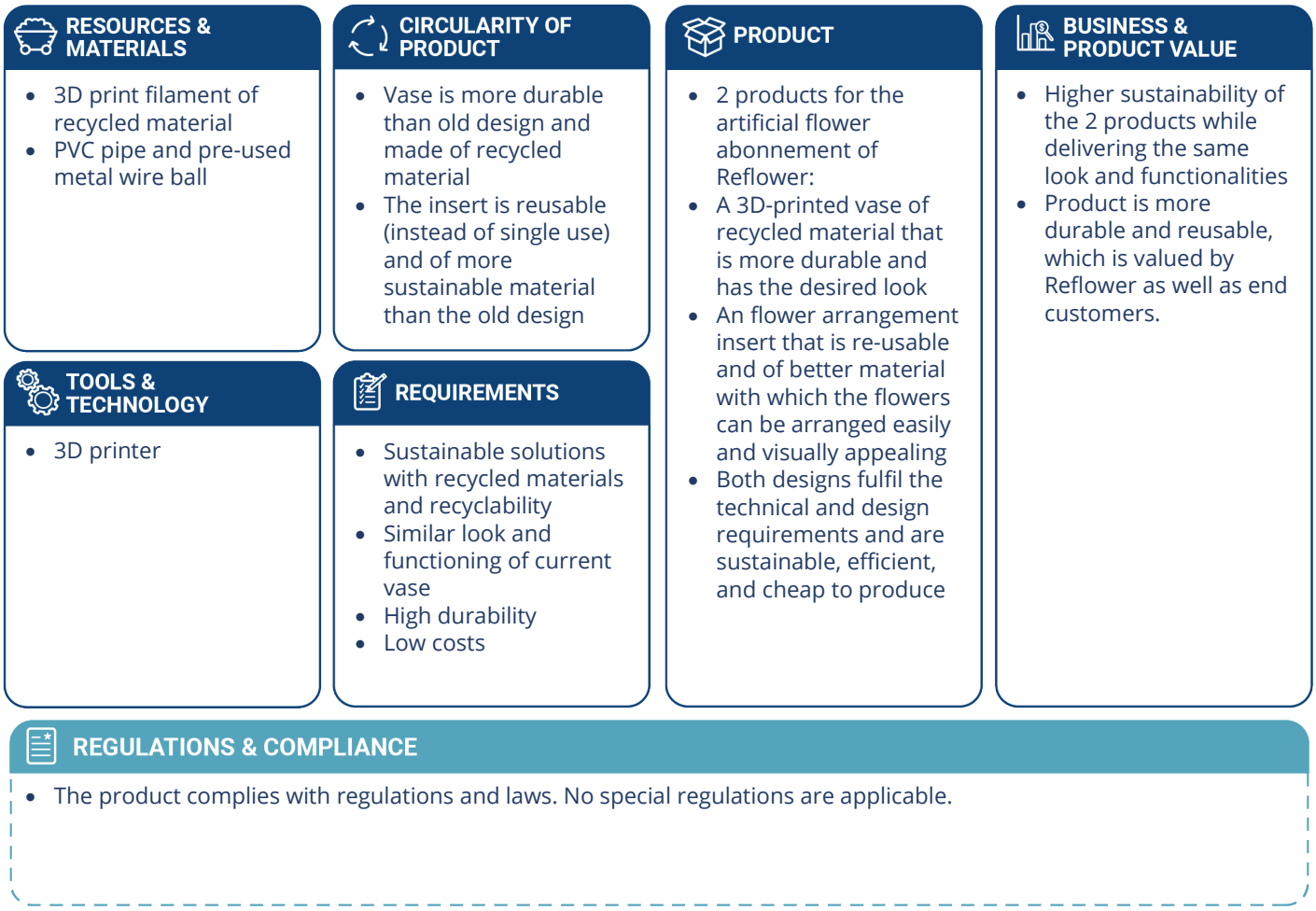


Figure 2: *CPC for Reflower*

Product

The business support delivered two developed products. One is a 3D-printed vase, made of a material containing recycled material developed in the TransformCE project, the other is a flower arrangement solution, an insert in the vase which can be used to arrange the bouquets. Both solutions can replace the former products.

The 3-D printed vase of recycled material and the arrangement insert were designed to fit the requirements of Reflower on aspects of costs, time to deliver, product features and design as well as sustainability.

The vase is drop and impact resistant, water-repellent and waterproof. The vase has a large neck opening so that the artificial flowers can be arranged in a good way. In addition, this vase is well within the budget of Reflower. The features fit the request of Reflower for a more sustainable vase, that is equally sustainable as visually appealing and functional. The vase will be used as a replacement for the current ceramic vases that Reflower uses for its flower arrangements.

The insert is made of a PVC pipe and a copper wire ball, it is easy and cheaply produced, reusable, and easy to use to arrange the flowers in a visually appealing way. The PVC pipe is used to keep the flowers at the right height and in the center while the wire ball is used to arrange the single flowers. It fulfils the wish of Reflower to have a more sustainable option to the single-use, oil-based arrangement product used before. Next to being much more sustainable, it is also functional and able to hold the flowers in a visually appealing way. The product will be used as an alternative to the current arrangement product.

"I can make a difference with the vases ... with them you can really show that you can make a difference"

- *Ellyne Bierman, Founder of Reflower*

Resources & materials

The vase is 3D-printed with a filament made of recycled material. The printing material used (PLA) was developed and provided by Manchester University as part of the Transform-CE project. The material is water resistant and will not absorb or otherwise be affected by the water. Theoretically the vase is watertight, therefore it is possible to make it heavier with water, sand or another material. This could prevent the vase from falling over if necessary. The vase is made of thicker layers, which makes the vase more resistant to heavy bumps and falls. The vase has a larger opening (11.5cm), so the artificial flowers can be placed at a very large angle. This makes it possible to create a very "lively" bouquet. The vase and the surface of the vase clearly show that it is 3D printed. The external characteristics correspond to the vases that users of Reflower are used to. The price of the vase is about €36, a price which can be reduced when larger quantities are produced. For the production of the vase, a 3D printer is needed, the design file and a person skilled to control the printer.

For the flower arrangement solution copper wire is needed that is formed into a ball as well as a PVC pipe. The copper wire can be acquired from scrap metal traders. Even though the PVC pipe is not made of recycled material, the solution can be seen as sustainable as they are very durable and can be used for a long time.

Tools & technology

Additive manufacturing (AM) will be used to manufacture the vase. A downside of the production via 3D-printing is that it is quite time consuming and material is more expensive than 'regular' material, the upside is of course that recycled material can be used and visually appealing as well as functional designs can be printed. Plus every vase can be changed (slightly) in the design and therefore unique or personalized.

No specific tools or technologies are needed for producing the flower arrangement insert as the wire ball can be easily produced by hand and be inserted in the PVC pipe. Pre-used wire can be used and the insert can be disassembled easily again increasing circularity of the solution.

Circularity of the product

The Reflower business model contributes to circularity as the artificial flowers can be re-used without loosing value. The production process and used materials for the production of the flowers is transparent. Through offering the bouquets on a subscription basis, re-use of the product is guaranteed.

The designed vase is made of recycled material (filament is produced in the TransformCE project) and more durable than the previously used vases. The vases used currently are mostly made of ceramic and break easily during transport. The newly designed vase on the other hand is drop and impact resistant because of the material chosen. At the end of the lifecycle the vase can be again recycled. The production chain of the filament used for printing the vase is transparent.

The arrangement insert is reusable (instead of the single use of the old product). It can be made of pre-used materials (PVC pipe, copper wire) and can be easily taken apart at the end of use and re-used for a different purpose.

Requirements

Reflower had several requirements for the redesign of the vase and an alternative for the flower arrangement insert.

- Costs: Reflower required the newly designed vase to have a similar cost as the old vase (7,50€ – 55€ depending on the size) and maximum costs for the insert of 5€. As 3D printing with recycled material is more costly than mass-produced products, the costs have to be kept in mind.
- Time: Reflower required a maximum delivery time of 1 month for the 2 products so it needed to be checked how long the production via 3D printing and delivery takes.
- Durability: Reflower required the vase to stay usable for 10 years and the arrangement insert to be more durable than the current product. Especially the durability of the 3D printed vase needed to be checked and taken into account in the design with potentially thicker layers to guarantee durability.
- Product requirements vase: Reflower required that the vase can be weighed down (so that it does not fall over), have a specific height, be drop resistant, be weather resistant (humidity changes and UV-radiation), and the vase should be sustainable (made of recycled material). In order to fulfill these requirements the choice for material and design had to be carefully checked.

- Product requirements arrangement insert: Reflower required the insert to be fitting into the designed vase, be sustainable (good recycling possibilities), be able to hold the flowers in place, be able to hold the flowers in a natural looking look and the arrangement process must not take longer than 15 minutes with the insert.
- End customer requirements: Reflower customers want to maintain the current type of look of the vase, and a natural look of the flower arrangement and they do not want to face higher costs.

Business and product value

The redesigned vase and insert are more sustainable than the previous counterpart and thus fit the goal of Reflower to be a sustainable company and deliver much more sustainable flower bouquets to its customers. The redesign delivers the same optics to end users while being more sustainable, a factor that the sustainability-minded customers of Reflower value. The (re)design tackles the problems of durability of the products, as the vase is more sturdy than the old product and made of recycled material and the arrangement insert is reusable and made of recycled material as well. The material is recycled, and recyclable and more durable than the old products.

Regulations and compliance

Both the vase and the insert comply with current laws and regulations. There are no special regulations concerning vase and insert.

3.2 Design, prototyping & testing

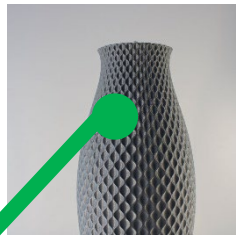
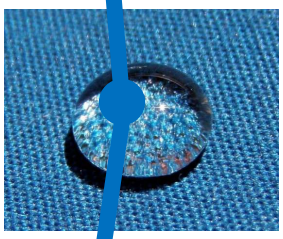
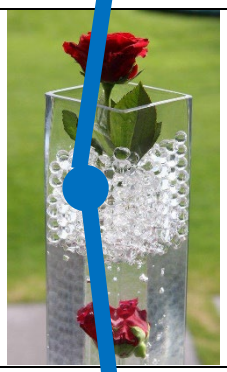
Option analysis:

Extensive analysis and testing has been done in order to find the best solutions for the redesign of the vase and insert that fulfil the given requirements.

First, it was analysed how the vase can contribute to the sustainability goals of Reflower. Until now sustainability did not play a role in the purchasing of the vases and there was no knowledge on the sustainability of the current vases. To improve this situation it was chosen to design a vase with a material that is recyclable and degradable. 3D printing makes it possible to use such material. The arrangement insert is unsustainable, as it is not reusable and is made of oil and resin, a better solution had to be found that offers the same functionality to arrange the flowers.

Different solutions for a vase design were compared with each other on topics of sustainability, efficiency, and price and the above-described requirements. Three materials were compared: cardboard, recycled plastic, and paper pulp. To fulfill the requirement of weather resistance, three coatings were considered. Three solutions were considered to make the vase heavy (sand bags, metal plates, glass). To guarantee drop resistance, the material was considered, the amount of layers and measures to prevent falling all together. Because sustainability has the highest priority in this redesign, the best solution was found to be a 3D printed vase made of recycled plastic, with a UV resistance coaring, weighted down with sand bags and made of multiple layers.

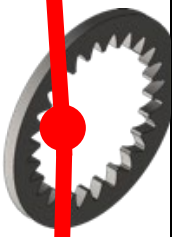
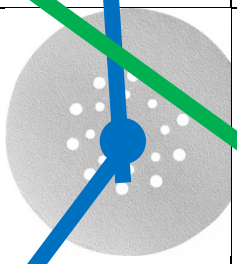
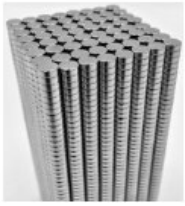
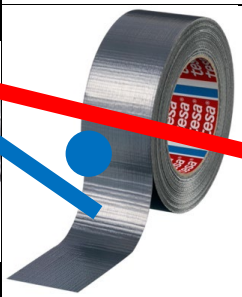
Table 1: Overview considered design options. The requirements are shown on the left and various ideas are displayed visually. The red line is the most efficient solution, the green the sustainable and the blue the cheapest.

	A	B	C
1. Sustainable material			
2. weather resistance.			
3. weighting			
4. drop resistance			

Similarly for the insert different options to fulfill the functional requirements for the insert were compared on the sustainability, efficiency and price. To determine the correct height of the flowers in the vase 3 options were compared, to keep the right position on the top of the vase, 4 solutions were compared, for keeping the position in the middle of the vase 3 options were compared, for

keeping the position in the bottom of the vase 5 options were compared and to secure the flowers in the vase 4 options were compared.

Table 2: Overview considered design options. The requirements are shown on the left and various ideas are displayed visually. The red line is the most efficient solution, the green the sustainable and the blue the cheapest.

	A	B	C	D	E
1. Height					
2. Position at top					
3. position middle		- 			
4. position bottom					

5. securing					

Tests:

To test which of the analysed options is the best solution multiple test rounds were done.
For designing the **vase** three tests were done and the required functionalities of the vase were tested. All tested designs were 3D printed vases, the first made of recycled trash, the second and the third of recycled coffee cups. The third test design was chosen as the best fit as it is drop and impact resistant, water-repellent and waterproof. The vase has a large neck opening so that the artificial flowers can be arranged in a good way. In addition, this vase is well within the budget.

Figure 1: 3D printed vases (from left to right, test 1, 2 and 3)

For designing the arrangement insert 6 rounds of testing were done with different materials and solutions. The solutions were tested on the functional requirements. After the test rounds it was concluded that the solution with a PVC pipe and a metal wire ball fulfills the requirements best.

Figure 2: Tests with different solutions

Figure 3: Difference in being able to create a 'natural look' of the flower arrangement. (Left: solution with a rooster. Right: solution with a metal wire ball)

Sustainability comparison of fresh and artificial flowers:

Additionally to the redesign of vase and arrangement insert, the sustainability of the artificial flowers versus fresh floriculture flowers was analyzed. This was not directly part of the Transform-CE business support was has been immensely helpful for Reflower in order to visualize the benefits and positive impact of their business solution. It was concluded that floriculture flowers have a negative impact on the environment, and that artificial flowers can reduce 146kg of CO_2 emissions a year and 18kg of waste.

4. Step 3 – Conclusion and recommendations

After going through the previously described steps, a wrap-up is presented in this chapter. This includes identifying the strengths of the redefined business model in regards to circularity, describing the learned lessons from the case study project and providing recommendations for the next steps.

4.1 Strengths of the redefined business model

Circularity of the product

The Reflower business model contributes to circularity as the artificial flowers can be re-used without losing value. Through offering the bouquets on a subscription basis, re-use of the product is guaranteed.

The redesigned vase is made of recycled material and more durable than the previously used vases as it is drop and impact resistant because of the material chosen. At the end of the lifecycle the vase can be again recycled.

The arrangement insert is reusable (instead of the single use of the old product). It can be made of pre-used materials and can be easily taken apart at the end of use and re-used for a different purpose.

Product (re)design, testing and/or prototyping

A thorough analysis of different options and their ability to fulfil the given requirements as well as an analysis of sustainability, efficiency and price was done for both the redesign of the vase and the flower arrangement insert. The solutions were tested in multiple rounds and a best fit solution was chosen.

The chosen design for the vase is a 3D printed vase made of recycled material, designed with multiple layers, is drop resistant, water-repellent, has a wide enough opening to be able to nicely arrange the flowers and is within budget. The chosen solution for the arrangement insert is a metal wire ball in a PVC pipe, it works best in easily arranging the flowers, holding them in place and enable a natural look of the bouquet.

4.2 Lessons learned

The newly designed insert with recycled and simple materials increases the circularity of the product considerably.

The newly designed insert which is separate from the vase enables new business possibilities, as clients can choose vase and bouquet separately from each other and it makes the transportation of the bouquets simpler, potentially making it possible to send the bouquet by mail solving logistic issues that the company faces.

The emission comparison of artificial flowers and floriculture flowers shows very clearly the positive impact that the upscaling of the use of artificial flowers can have on sustainability.

4.3 What's next

Reflower is continuing the improvement of their business model and product making it still more sustainable and circular. They also invest in raising awareness of the impact that can be had from using artificial rather than fresh floriculture flowers and the advantages of their subscription business model. Through growing their business they hope to increase sustainability and deliver a contribution to reaching the Sustainable Development Goals.

The chosen designs for vase and insert could be further improved through testing other designs, materials and production methods. Another possible case for the improvement of the Reflower circularity is finding solutions for the end-of-life of the artificial flowers. The results of the business support can potentially enable new business models.

References

Brzesowsky, S.; Buwalda, R.; Telemaque, S.; Schaling, G. (2022) Onderzoeksrapport naar de CO_2 impact van kunststofbloemen aan de hand van een dashboard. Reflower. Hogeschool Utrecht. Utrecht.

About the project

The problems associated with plastic waste and in particular its adverse impacts on the environment are gaining importance and attention in politics, economics, science and the media. Although plastic is widely used and millions of plastic products are manufactured each year, only 30% of total plastic waste is collected for recycling. Since demand for plastic is expected to increase in the coming years, whilst resources are further depleted, it is important to utilise plastic waste in a resourceful way.

TRANSFORM-CE aims to convert single-use plastic waste into valuable new products. The project intends to divert an estimated 2,580 tonnes of plastic between 2020 and 2023. Two innovative technologies – intrusion-extrusion moulding (IEM) and additive manufacturing (AM) – will be used to turn plastic waste into recycled feedstock and new products. To support this, an R&D Centre (UK) and Prototyping Unit (BE) have been set up to develop and scale the production of recycled filaments for AM, whilst an Intrusion-Extrusion Moulding Facility, the Green Plastic Factory, has been established in the NL to expand the range of products manufactured using IEM.

Moreover, the project will help to increase the adoption of technology and uptake of recycled feedstock by businesses. This will be promoted through research into the current and future supply of single-use plastic waste from municipal sources, technical information on the materials and recycling processes, and circular business models. In-depth support will also be provided to a range of businesses across North-West Europe, whilst the insights generated through TRANSFORM-CE will be consolidated into an EU Plastic Circular Economy Roadmap to provide wider businesses with the 'know-how' necessary to replicate and up-scale the developed solutions.

Lead partner organisation
Manchester Metropolitan University

Partner organisations
Materia Nova
Social Environmental and Economic Solutions (SOENECS) Ltd
Gemeente Almere
Save Plastics
Technische Universiteit Delft
Hogeschool Utrecht
Hochschule Trier Umwelt-Campus Birkenfeld Institut für angewandtes Stoffstrommanagement (IfaS)
bCircular GmbH

Countries
UK | BE | NL | DE

Timeline
2019-2023

www.nweurope.eu/transform-ce