Interreg
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Business support – case study 20302050

Redesigning products with recycled plastic feedstock

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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 20302050, 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).

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

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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 February 2023. 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.

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[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
Step 1: Initial diagnostic	Guido de Vries	Owner, director and founder
Step 2: Circular product development	Guido de Vries Marije Vermeulen	Owner, director and founder Designer, projectmanager
Step 3: Circular product management	Guido de Vries Marije Vermeulen	Owner, director and founder Designer, projectmanager

[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

20302050 wants to offer companies, municipalities and consumers a new and feasible perspective! 20302050 contributes to the necessary transition from a linear to a circular economy with knowledge, experience and energy. 2030-2050 does this by stimulating people, organizations and companies to take on challenges and by providing problems with a new and feasible perspective, aimed at the future. 20302050 supports changes with inspiration, connection and developing new products (https://20302050.nl/).
A short overview of 20302050 is given in table 2.**Error! Reference source not found.**

Table 2: Overview of company

Topic	Information
Company name	20302050
Website	https://20302050.nl/
Country	The Netherlands
Size of company (0-10, 10-200, 200-500, 500+ employees)	2 employees
Mission/vision	Establishing a world which is cleaner, fairer and more sustainable by reframing problems with a new and feasible perspective, aimed at the future
Value proposition	20302050 contributes to the necessary transition from a linear to a circular economy with knowledge, experience and energy.
Main activity	Consultancy, networking, production

2.2 Current situation & challenge

One of the main focuspoints of 20302050 is to stimulate the circular economy and to address other sustainable challenges, such as climate change, water shortage and urban heat stress. In line with these goals 20302050 wants to produce a rain barrel which for usage in an urban environment. Ideally the size of the rain barrel is 30x30 which is the size of a dutch sidewalk tile, so the rain barrel can be places in the space of a sidewalk tile.

Necessary requirements (must haves):

- The rain barrel (30x30x140) should be produced from low quality consumer plastic waste, (which would end up in the garbage incineration otherwise). The Dutch company 'Save plastics' processes this type of plastic waste and can produce rectangles (size xx) as raw material for this rain barrel.
- In the design and production of the rain barrel no new polluting materials are used.
    - The rectangles are connected without using new polluting materials (e.g. certain types of glue). The connection must be made with the plastic rectangle itself (using

a mechanical connection) or by adding natural connecting means such as flax. The use of screws is possible if needed.

- Other options of producing the barrel by e.g. bending the plastic shelfs or pressing the raw material in a mould have to be researched;
- The material should be strong enough to contain the water and should not bend.
- Using an extra waterbag inside the barrel is not preferred but also an option.
- It must be easy to connect the watertap to the barrel. The design of the watertap isn't fixed, so suggestions on the design and material of the tap are welcome as well.
- An important requirement, is that the rain barrel is watertight, so no leakage is possible.

Other requirements (nice to haves)
Extra features of artistic value or added consumer convenience, both installing the barrel as using it, are welcome. A flower box on top of the barrel is a wish as well.
As the barrels must be produced somewhere and transported to the customers, advices on these topics are welcome as well. A 'nice to have' would be to have a temporary plastic factory in a neighbourhood where the consumer waste is directly transformed in the components of the barrel.

First of all the technical options will be researched and tested, afterwards the possibilities for the 'nice to haves' will be addressed.

Desired advice on production and management of the rain barrel

- How to upscale the production? How many rain barrels can be produced daily with the intended material and design?
- Is it possible to re-use local plastic waste? (consumer waste or garden furniture etc.) Setting up a local pop-up recycling factory in a neighbourhood?
- Is it possible to recycle the rain barrel again? How do we organize the return flow?
- How can we best distribute and assemble the rain barrel?
- What do the different solutions cost?
- Can we involve people with a distance to the labour market in the production or distribution?
- Can we print a logo on the rain barrel?
- How to repair the rain barrel? Who is responsible for maintenance?

Description of support

- Investigate technical options to manufacture a rain barrel from low quality consumer plastic waste.
- Investigate collaboration options with Save Plastics and municipalities
- Advise in setting up and upscaling production
- Advise in assembly options (do it yourself) and distribution possibilities.
- Advise in design

    - customized extra’s to enhance user satisfaction
    - possibilities to enhance attractiveness
- Prototype of the rain barrel

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 20302050 is visible in figure 2 and a description of each element is given below.

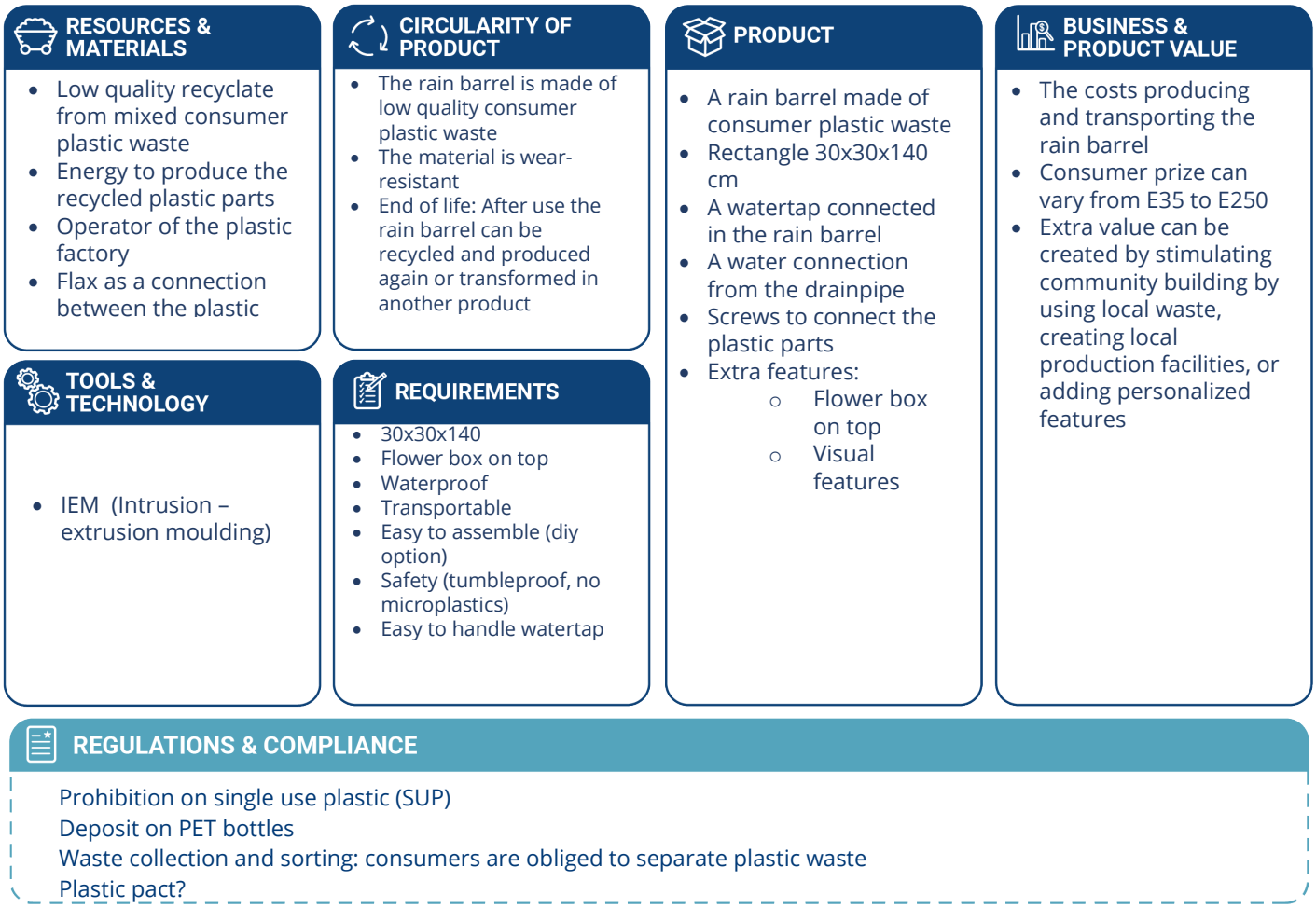


Figure 2: *CPC of rain barrel for 20302050*

Product

- 20302050 wants to produce a rain barrel, size 30x30x140, preferably made of low quality mixed consumer plastic waste.

Resources & materials

- For the production of the rain barrel is needed: low quality, mixed consumer plastic waste, collected and sorted.
    - During the Transform-CE project, the IEM technology and material of the green plastic factory (https://saveplastics.nl/) is used on the site of the local waste recycler 'Cirwinn' in Almere
    - After the project is over, other ways of collaboration with landfills, communities and Save Plastics or other providers and manufacturers should be considered.
- Furthermore we need IEM (intrusion – extrusion moulding) machinery and moulds with which the plastic waste is processed to usable shapes
- Other parts we need for the rain barrel:
    - Flax and screws as a connection between the plastic parts
    - Water taps
- Required energy:
    - to produce the recycled plastic parts
    - to transport the plastic parts/ or assembled rain barrel to the customer
- Vehicle(s) to transport the rain barrel to the customer
- Human resources
    - designers of the moulds and constructions of the rain barrel
    - operators of the plastic processor.

Tools & technology

For the testing en prototyping we need:

- Intrusion and extrusion moulding technology and machinery
    - For the research and testing one extruder will be used
    - For upscaling the production after testing more machinery will be necessary
- Tools to mechanically process (sawing, bending, etc.) the boards
- Boards of Save Plastics for experimenting
- Flax
- Solder
- Steel (for making the mould)

Circularity of the product

- The rain barrel is made of low quality consumer plastic waste
    - If desired the consumer plastic waste can be collected locally
- According to tests the material is durable and weather resistant and has an estimated lifetime of at least 20 years, depending on the thickness of the wall of the rain barrel and the conditions in which it is used (sun or shade).
- Repair and maintenance: after easy installation which anyone should be able to do, the barrel is largely vandalism-proof, so damage is not to be expected. If damage occurs (e.g. the tap) individual parts can be easily replaced.

- End of life: after use/end of life the rain barrel can be taken back by the producer and be recycled and produced again or transformed in another product. This was tested at the University of Applied Sciences, Utrecht: the material could be recycled 8 to 9 times without loss of quality ("Save Plastics, Saving the Environment from Plastic", P. Vijfhuizen, E. Poos en A. Knopper, minor-report Hogeschool Utrecht, 2023.).

Requirements

- The desired dimensions are 30cm x 30cm x 140cm (Taking into account the inner dimensions (26x26x140) this will be approximately 95 liters)
- Flower box on top
- Waterproof
- Transportable
- Easy to assemble (diy option)
- Safety (tumbleproof, no microplastics)
- Easy to handle watertap
- Recyclable by the manufacturer

Business and product value

The purpose of the rain barrel is:

- Water retention
- Greening the urban environment by providing easy to access water
- Saving plastics from incinerating and reducing CO2 emissions

Non-material values:

- Stimulating social networks in installing and using the rain barrels
- Creating awareness of the amount of plastic waste and the everlasting life of it

Financial

- Co-financing by municipalities is a possibility

Regulations and compliance

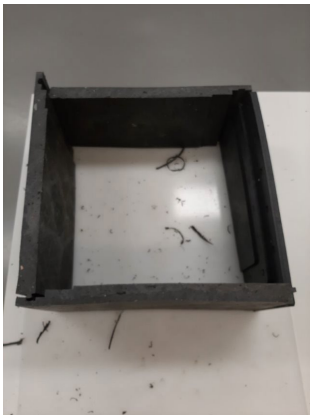
- Product safety
  - There are no specific guidelines for rain barrels. There is a small risk in case of frost if the water freezes and expands a barrel can be damaged.
- Other legislation concerning plastic
  - Prohibition on single use plastic (SUP)
  - Deposit on PET bottles
  - Waste collection and sorting: consumers are obliged to separate plastic waste
- Subsidies which might be possible to claim, producing a rain barrel:
  - Some municipalities subsidize the purchase of a rain barrel: https://lokaleregelgeving.overheid.nl/CVDR654240/1; https://www.duurzaambouwloket.nl/maatregel/regentonnen

3.2 Design, prototyping & testing

Joris van Tubergen, industrial designer at the university of Applied Sciences Utrecht involved in Transform CE, designed and tested several possible options for the rain barrel, working with the low quality consumer waste of Save Plastic.
Stefan Schoegje, plant manager of Save Plastics in Almere, was involved in the design and testing process as a specialist in working with low quality consumer plastic waste.
In this section we will describe the different stages of testing the design ideas we had.

Mechanical connections and welding

Initially we focused on connecting the rectangles mechanically, anchored by a profile where you can press both pieces together. The edges of the rectangles were sawn in construction grooves and put together in a tongue and groove joint. The connection was strong and not difficult to make, but not 100% watertight. Screwing the parts together turned out to be no problem: the material is suitable for screwing.



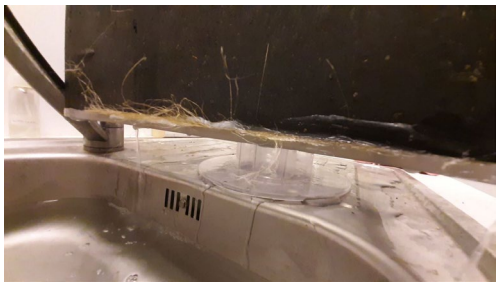
NB: Instead of sawing the profile after producing the shelf, it is also possible to make the groove in the mould of the shelf.

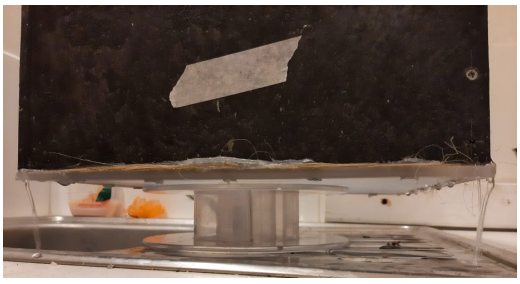
The designer also tried plastic welding techniques. Welding is possible with this material, but the connection is not strong enough. Welding is a good option to get the seams water tight. But the plastics are too low grade to get a mechanical connection which is good enough for the construction.

In the second design the designer experimented with hemp and vaseline in the tongue and groove joint (similar to old school caulking a ship).

This did improve the watertightness but not very convincing; the water pressure of a rain barrel of 1.40 meter is very high, so the connections must be very strong.

Screwing the bottom of the box on the sides with flax and Vaseline





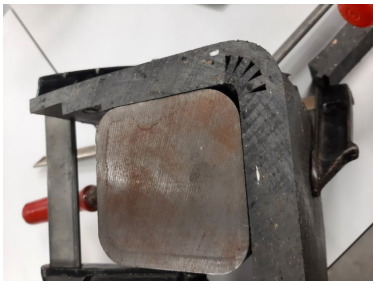
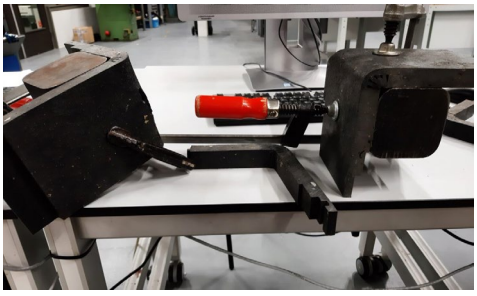
Leakage of the water



Adjusting kit on the outside of the seam decreased the water leakage

Bending


In the third design we tried to bend a plastic shelf when it was still hot. This worked out rather well, though there was a risk of cracks. This option is rather innovative for other products as well since you can easily make higher products than the constraints of the press. In this experiment the bending is done afterwards, but maybe the bending can be done straight after pressing. Another option is to make use of local cooling on the parts which are not allowed to bend and therefore only the 'hinge' can bend.

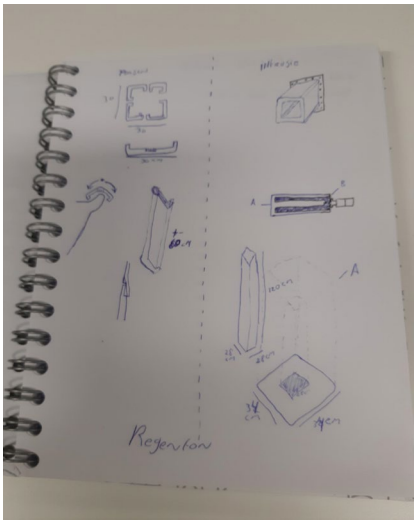
Variations on the original design

In the design process we also considered the possibility of making a two-piece construction of a basic box with a top box. With the press mold you can press a board with edges and ridges, which you can press against each other. In this way the rain barrel can become higher by sliding two (or three) pieces into each other. Extra advantage is that the connecting ribs make the barrel stronger. Also the idea of two smaller rain barrels next to each other was discussed. This can be used as a flower box or a bench.

Another design idea was to put a plastic bag in the rain barrel to make it waterproof. The bag can be connected to the tap.

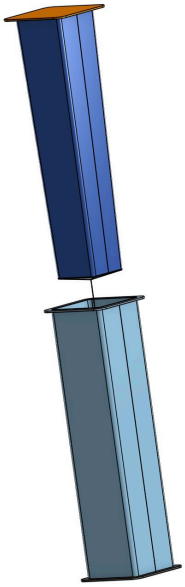
Though both ideas were good options as well, we stuck to the original design.

Intrusion in a mould



The first design of the mould by Stefan Schoegje (Jan'2023)

Discussing the design possibilities with Stefan Schoegje of Save Plastics resulted in considering the possibility of pressing the plastic material in a mould. This possibility will be further developed and tested in spring.
This intrusion requires a lot of pressure, the question is whether this will work over such a long, thin surface. Injection from the side could be an option to reduce the pressure.
A disadvantage is the cost of the mould and the associated risk if it will not work.
For all designs the weight is challenging. A rough estimate is 40 kg per barrel. This is, however, an advantage once the barrel is installed in place.



The intrusion mould designed by Joris van Tubergen (Jan 2023) →

Connection of the water tap
The connection of the tap to the barrel can't be too low, because of the watering can that comes underneath. But because of that there is still a layer of water underneath. There are two possible solutions: a second tap to let water run out or a raised bottom.
Also important in the design, is the connection of the tap into the rain barrel. It is possible to make screw thread in the barrel, but that connection is too weak if you bump to it.
Another point of research is what has a better functionality: a drip stop or of a tap?

Operational consequences of choices of material & design
Weight
The total rain barrel will be heavy. The shelves can't be thinner, because than it becomes too weak and will bend.
Weight is therefore a hard precondition: the total weight will probably be around 80 kilos.
As a customer you will need help in transport and installation.

Installation of rain barrel (design: screwing together the rectangles)
Assembling the rain barrel is not very difficult when it is a matter of screwing parts together. So customers can do it themselves. Otherwise the carrier could assist the assemblage and installation.
If the municipality is the customer, they could possibly also provide transport.

Weathering and distortion
Bases on experiments and experiences so far, don't we expect that the material will disintegrate or distort easily. So for now, this is no point of concern.
However we don't know how the joints will react when frost will extend the water column. This is a risk we have to investigate with a prototype.

Price
Cost price: the different designs imply different prices. As a maximum we decided 200 euros per ton is still a reasonable price.

Safety
Safety is also an important design criterium. The barrel mustn't fall over on children, if you hang on it. If necessary a mounting bracket can be made to attach the barrel to the wall. However considering the weight of the barrel, even when empty, falling over is not probable. To be sure, this can be tested with the prototype.

Appearance
For the awareness and the image of the municipality it is good to see that the barrel is made from recycled material. In the research of the Transform CE group on consumer behaviour it showed that a recycled look is also attractive to consumers.
Other design features can be added to customize the barrel, such as:

- Water and food bowl for birds attached.
- A flower box on top
- A mark of the neighbourhood
- Etc.

Production speed
Production speed with the intrusion mold: it takes 4 to 8 hours including cooling. So with one mould you can produce 2 barrels a day.

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

We think a rain barrel of recycled single use plastic (SUP) feedstock is producible. This is of course the ideal way of upcycling low value plastic waste.

To make the product completely circular, it is also important to think of collecting the rain barrel after use. Though we think (based on experience with street bollards and furniture) that the rain barrel will last years without major quality loss, people have to be able to return the barrel even before end of life.

Product (re)design, testing and/or prototyping

The plastic material is strong and easy to process. Pressing the material in a mould is possible and rectangles, shelves or (small) boxes can be made. After production it's possible to process the shelves mechanically: sawing and screwing, but also bending is an option.

However there are **some challenges:**

- *the height of the mould*: intrusion of the plastic material in a mould of 1.40 x 30 x 30 might be difficult. When this isn't working out well, there are some alternatives:
  - making a lower rain barrel (120 x 30 x 30) with a separate flower box on top;
  - assembling a rain barrel of the same size (140 x 30 x 30) out of two parts;
  - constructing a rain barrel of 70 x 70 x 30 (make a broad rain barrel which can be used as a garden bench);
  - other construction options combining the techniques discussed before (bending, groove and joint, etc.);
- *the production process*: producing the barrel will be rather time-consuming. It takes 4 – 8 hours to fill the mould and to cool the material. Upscaling would imply to purchase several moulds, so parallel producing is possible;
- *the weight of the rain barrel*: because the sides of the barrel can sag, they have to be quite thick or supported by several ribs. The estimated weight will therefore probably be at least 80 kilograms;
- transporting and assembling the barrel: because of the weight it might be hard for consumers to transport the barrel themselves. Assembling will not be very difficult, but, again, because of the weight, this can be a challenge as well.

4.2 Lessons learned

Apart from the technical insights we collected some insights on the design process and business interests as well.
As 20302050 had several orders waiting for the rain barrel already, they were searching for a rapid solution. As a result a long process of research, designing and testing was not in their immediate interest. They therefore decided on a twofold approach to look for a manufacturer who could produce a barrel with recycled plastic (though less low value) and in the mean time look for a better solution in which low value SUP is used to produce the barrel.
This implies that a rapid design and prototyping process can be crucial for future companies who want to use recycled single use plastic (SUP) as feedstock.
Apart from this it is also important to anticipate in the design process on:

- the upscaling possibilities of the production of the product. As the production speed can be an important factor in the business strategy this must be taken into account designing the product;
- the transport and installation/assembly of the product;

4.3 What's next

The results of the researching, designing and testing show the possibilities of processing the recycled single use plastic (SUP) feedstock into a rain barrel. The advantages in environmental gain of re-using this type of plastic waste instead of incineration are obvious. However there our also challenges in producing the barrel and if successful in the characteristics of the product.
20302050 has several possibilities to continue with this project:

- Continue the collaboration with Utrecht university of Applied Science and/or Save Plastics, trying to further design and prototype the 'ideal rain barrel';
- Rethink the dimensions of the rain barrel;
- Considering producing other products which can be made of recycled single use plastic (SUP)

Utrecht university of Applied Science will hopefully be able to continue researching, designing and testing the possibilities of recycled single use plastic (SUP) feedstock. This can be explored in student projects, both in collaboration with Save Plastics and/or other suppliers.

References

"Save Plastics, Saving the Environment from Plastic", P. Vijfhuizen, E. Poos en A. Knopper, minor-report Hogeschool Utrecht, 2023.

https://20302050.nl/ Website of 20302050
https://saveplastics.nl website of Save plastics
https://saveplastics.nl/oplossingen/groene-plastic-fabriek/ Save plastics factory in Almere
https://www.nweurope.eu/projects/project-search/transform-ce-transforming-single-use-plastic-waste-into-additive-manufacturing-and-intrusion-extrusion-moulding-feedstocks-and-creating-a-new-circular-economy-model-for-nwe/ Site of Transform CE

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