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Business support – case study Searious Business

(Re)designing 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 Searious Business, 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 D3.4 Redesigned products with AM
WPT3 D3.5 Redesigned products with IEM
WPT3 D3.7 Redefining Circular Economy business models

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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.

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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
Jaap Patijn	Design Engineer at Searious Business
Stefan Schoegje	Branch manager at the Green Plastic Factory

[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

Searious Business offers solutions for circular plastic use. They help their clients with redesigning products and packaging and with rebuilding business models for sustainability. They aim for keeping plastic within the economy and out of the environment by tackling the plastic problem at the source. The company offers circular solutions for packaging, consumer electronics and furniture. A short overview of Searious Business is given in table 2.

Table 2: Overview of company

Topic	Information
Company name	Searious Business
Website	www.seariousbusiness.com
Country	The Netherlands
Size of company (0-10, 10-200, 200-500, 500+ employees)	0-10
Mission/vision	"Zero plastic waste into our ocean"
Value proposition	Searious business offers solutions for circular plastic use and help their clients with redesigning products and packaging as well as with rebuilding business models.
Main activity	Design of sustainable products and packaging

2.2 Current situation & challenge

The idea of this business support is initiated as part of the project 'Plastic Waste Free Islands' (PWFI)[5], an international project focussed on limiting plastic waste in the Pacific and the Caribbean. Within the project, the waste streams and markets of six islands[6] have been analysed. The landfills of these islands are filling up. The project explores new ways and opportunities to make new products out of the plastic waste on the islands. Together with the Green Plastic Factory[7] Searious Business has taken up the task to design and develop a circular park bench. The goal is to use the moulds of the park bench in recycling set-ups on the islands'. This way, benches can be made from

[5] The PWFI project part of the Close the Plastic Tap program of IUCN (Intenational Union for Conservation of Nature). For more information see: https://www.seariousbusiness.com/blog-50-shades-of-green/tropical-the-island-breeze-all-of-nature-plastic-free

[6] Antigua, Barbuda, Saint Lucia, Grenada, Fiji, Samoa and Vanuatu

[7] The Green Plastic Factory is one of the pilot plants from the TRANSFORM-CE project, which uses IEM technology to transform low-quality mix-plastics into new products.

local waste, for local applications. The chosen solution is aiming to process HDPE, PP, LDPE and a so called 'dirty' mix of plastics.

Description of support

The support throughout this project is focussed on the design of the park bench, making the moulds and testing, prototyping and creating first products. At a later stage, further support may be offered with setting up a small plant on one of the islands. Next to this, the Green plastic Factory also helped with mapping the possibilities and limitations of using IEM technology.

"The Green Plastic Factory has this hands-on mentality, we just have to do this."

- *Jaap Pattijn, Design Engineer at Searious Business*

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

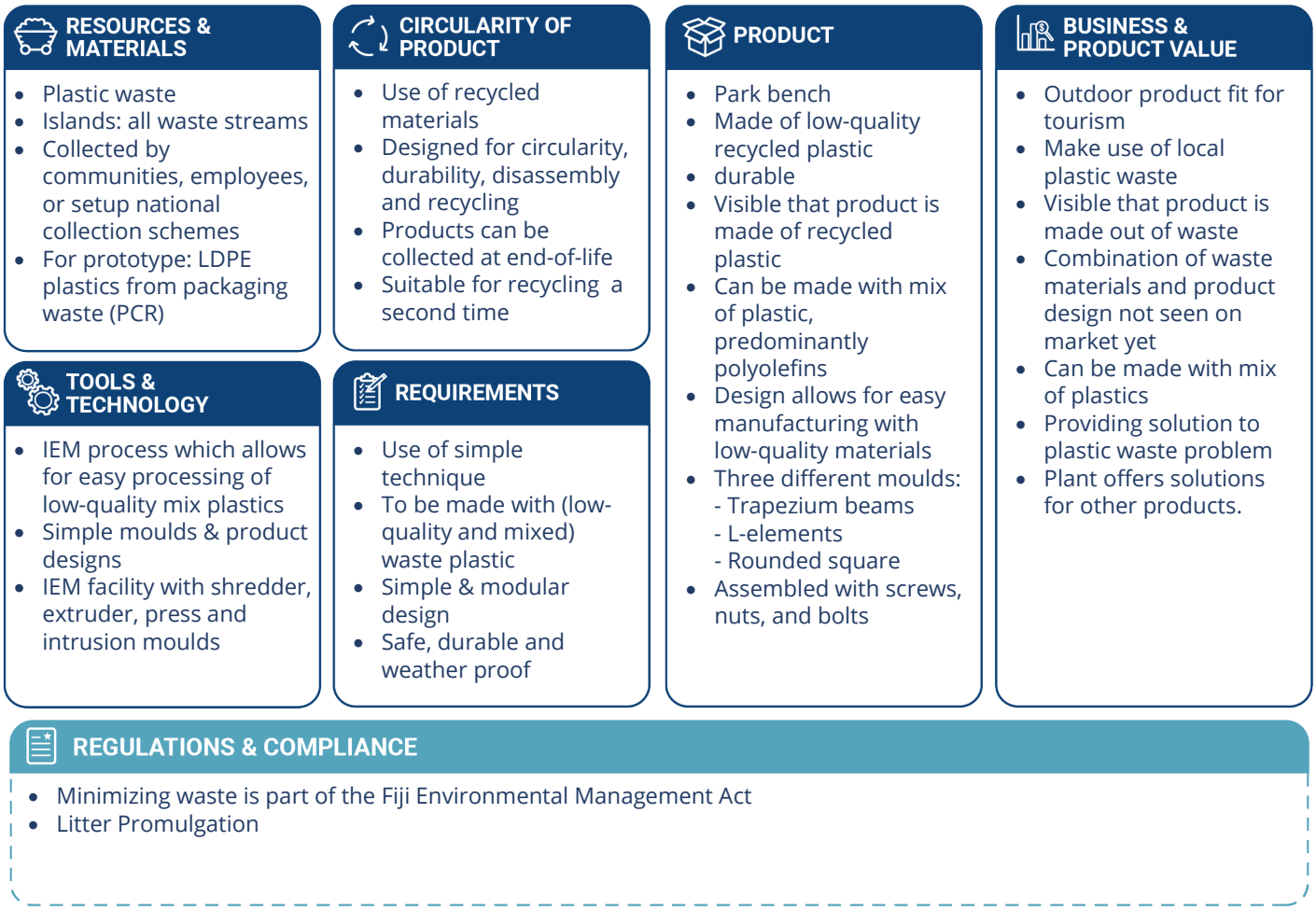

Figure 2: *CPC for Searious Business*

Product

The final product is a park bench, made of local recycled waste plastics. The bench is a unique product, not only due to its characteristics and appearance, but also because it will be made of waste plastic. It should be visible to the unaided eye that the product is made out of recycled plastics. The product is designed in such a way that it can be made with a mix of plastics. The reasons for this is that it's sometimes hard and expensive to process, segregate and washes the different polymers

The product design consists of several elements that can be made with three different moulds (bar, L-element and rounded square). It is designed in such a way that it can be made with mixed plastics. See also figure 3 for the design of the product, and the three elements the bench is made of. The parts are assembled by means of screws. The bench is designed in such a way that it can be easily disassembled to, for example, replace a certain part.

Figure 1: Design of the park bench

Resources & materials

For the material input, several waste streams have been explored in the PWFI project, which includes bottle-to-bottle recycling (PET), the use of fishing gear (PA) and other waste plastic (PE and PP). The latter has been chosen for the development of this project and the design of the park bench, because it is a big waste stream, it is easily moulded, and relatively safe when heated.

The input material will differ for the location where products are produced. Input material is generally low-quality waste. On the islands, products are likely to be made from plastic, as a lot is imported and there is a large tourism industry. Hotels and resorts are actively collecting there plastic waste, promoting sustainability and their sustainable image.

The first prototypes manufactured in the Green Plastic Factory, are made with agglomerated LDPE (polyethylene) , but may also contain other plastics. All plastic comes from packaging waste after usage by consumers (post-consumer recyclate, PCR).
If an IEM facility will be placed on one of the islands, everything will have to be set up on location. Several machines are needed for this, which includes a shredder, extruder and press. The moulds are property of the project. Knowledge about IEM technology and setting up such a facility will also be an important asset.

Tools & technology

At the start of the project, Searious Business looked into the use of several technologies and plant set-ups. Which will be the best match for their concept? On one hand, the set-up should not be too large, as this will require big investments. On the other hand, Searious Business would like to make enough impact and is looking for ways for the concept to be profitable for local businesses. Hence, the set-up should also be able to process a sufficient amount of waste. With the help and advice of The Green Plastic Factory, the choice was made to use Intrusion-Extrusion moulding (IEM) technique[8].
The idea is to manufacture the benches on the island itself, with just a simple set-up. The benches will be made with plastic, which will be washed, shredded, or agglomerated, extruded, pressed into the mould and then cooled before the finished product is assembled by hand. The IEM process used for this allows for easy processing of plastics, but also comes with the limitation in product design. No complex mould designs (for example sharp edges) can be made using this process, which is taken into account in the design of the product.

Circularity of the product

The circularity of the product includes the use of recycled materials, collected on the islands. The product is designed for durability and can last up to 50 years. The design allows for easy disassembly, to offer the possibility to replace broken or damaged parts. At the end of the product's usage period, the benches can be collected and the material can then be used again as input for new products. The goal is to preserve materials for as long as possible and with each cycle something new can be made. The same production facility can be used for shredding and reprocessing of the material.

"The product can be taken apart just as easily as it is put together."
- *Stefan Schoegje, branch manager at the Green Plastic Factory*

[8] IEM: Intrusion-Extrusion Moulding is a technique specially designed for the use of low(er) value recycled materials. The process is 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 (intrusion).

Requirements

The most important requirement of the concept is to manufacture products with a simple technique. The products should be made of (low-quality and mixed) plastic. For the product it is important that the design is simple, modular and that parts can be replaced when needed. Other requirements for the product are that the bench is attractive in its appearance, that it is safe, durable and weather proof, fitting the sun-sea climate of the islands.

In more detail, the design process of Searious Business resulted in the following requirements:

Customer/user requirements

From a customer perspective, it is important that the product is resistant to vandalism, durable and safe. Users desire an attractive looking product and a bench which is safe and comfortable to sit on.

Technical requirements

The most important technical requirements are to make sure a person of max. 150 kgs can sit on the bench and that the product is weather proof (UV resistant, rainfall, storms and salty water). Moreover, it tends to get quite warm on the islands, so it is important for the product not to deform or weaken due to the high temperatures. The product will probably heat up and be hot when touched, but this happens with all kinds of products placed in the sun.
Moreover, the idea is to manufacture the benches on the island itself, with just a simple set-up. Important here is to ensure a stable power supply, which can be a challenge to achieve on islands.

IEM process and feedstock requirements

When using the IEM process, the only requirement for material input is a high percentage of polyolefin, to secure moldability and strength. Furthermore the products can be manufactured with high contaminations. However, materials from pure polypropylene (PP), or pure polyethylene (PE) are preferred, which is usually the largest fraction of plastic collected.

Design requirements

In terms of design, one of the most important aspects to take into account is the limited size of the machines, meaning that the moulds should be designed to fit a press of 60cm x 60cm. The product is designed in such a way that the separate elements are not larger than this. For longer beams, an intrusion mould can easily be added. A draft angle is required for the press moulds, allowing parts to be easily removed after manufacturing.
Using the IEM process also comes along with more specific requirements for the product design and used moulds, as only relatively 'simple' parts can be manufactured. This means, for example, no products with sharp edges, which is taken into account for the product design. Even with these limitations in mind it is still possible to create an attractive product design.

Circularity requirements
Other requirements in terms of circularity are to make sure the products can be easily disassembled and that the product is designed to last for over 40 years.

Business and product value
For each of the islands, tourism is a very important source of income. When using recycled plastics, it is desirable to manufacture products that will be outdoors. This combination led to the design of a park bench, suitable for public spaces and used by tourists and locals.

The bench is a unique product, not only due to its characteristics and appearance, but also because it will be made of local plastic waste. The aim of this concept is to clearly show that the product is made of waste. It should be visible to the unaided eye that the product is made out of recycled plastics. This way, it also does not matter if there are some imperfections in the final product. Even better, imperfections are desired in order for the user to see that valuable products can be made out of waste, therefore, it is ok to leave contaminations in the feedstock. The product stands out due to its design and the choice of materials, which is not a combination seen on the market yet.

The park bench has been designed and developed in consultation with the Green Plastic Factory. The moulds are now IUCN's property, and will be used on the islands. The park bench is designed in such a way that it can be made with all kinds of plastics. The aim is to set up a small scale production plant in on the islands in the Pacific and the Carribean, to make the benches from waste collected on the islands.
Searious Business is doing this work as part of the PWFI project, which is subsidised by IUCN. This project also represents the company's vision to offer solutions for circular plastic use. Searious Business would like to make an impact by tackling the problem at the source.
The park bench functions as an example of a product that can be made with the set-up and chosen techniques (IEM). However, it will not be the only product that will be made as the business is supposed to grow and the product range will expand. The product concept designed and developed for the targeted islands can also be implemented in other regions and countries, and thereby presents opportunities for scaling up this project for Searious Business.

Regulations and compliance
The Environmental Management Act 2005 state that it is the public authority's responsibility to minimise waste. In 2008, Litter Promulgation was published, focussing on regulating, prohibiting, and managing litter (SPREP, 2018). Even though, a lot of waste still ends up in the environment and ocean, and enforcement seems to be lacking. Both government and inhabitants will be happy that the beaches are cleaned up. All local legislation is followed and in many cases the local government is involved in the project. All safety precautions during production are considered.

3.2 Design, prototyping & testing

Searious business benefited from a close cooperation with the Green Plastic Factory. Whereas the product idea came from Searious Business, engineers from the Green Plastic Factory shared their experience and knowledge on the use of plastic waste in processing. This also included designing the moulds and creating and testing first prototypes. Another important part of the support was highlighting the possibilities and limitations of using IEM technology.

Product design

The park bench has been designed by Searious Business. The final product design can be seen in figure 4. The design consists of three different elements: bar (multiple pieces), L-element (2x) and rounded square (2x), see also figure 5. The first idea was to create a bench that fits multiple people. However, it soon turned out that the bars would bend. Hence, it has been decided to create a seat which fits only one person, to prevent sagging of the product.

Figure 3: *Final product design of the park bench*

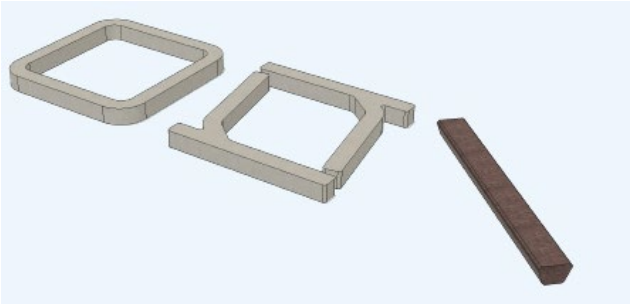

Figure 4: *Three different parts: bar, L-element and rounded square*

Mould design

The advising role of the Green Plastic Factory in this project also included their expertise in low-cost mould making and the usage of this mould with IEM technology. To create the park bench, three different moulds are required, one for each of the elements. Each mould is a simple design with rounded corners, which allows for easy manufacturing when using low-quality materials. The

moulds include a draft angle, allowing for easy removal of the piece from the mould. The draft angle prevents the mould to be laser cut in one go. Therefore, each mould is built up of several sheet metal layers, which are laser cut individually and then stacked on top of each other to form the final mould. This also ensures the moulds to be less expensive. The mould designs and the final moulds can bee seen in figures 6 and 7 respectively.

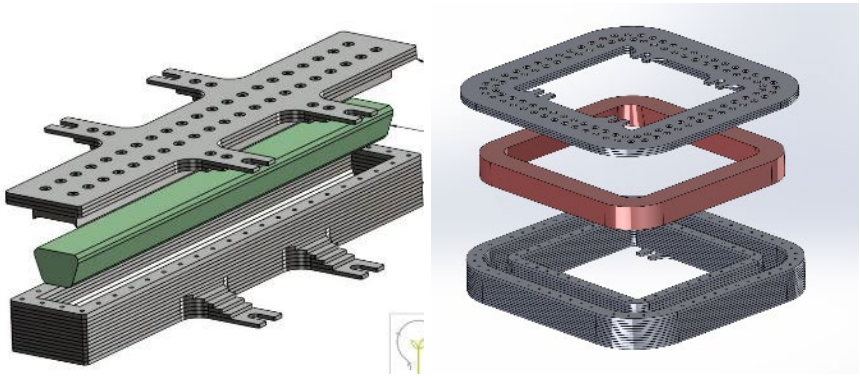

Figure 5: *Mould design of bar (left) and rounded square (right)*

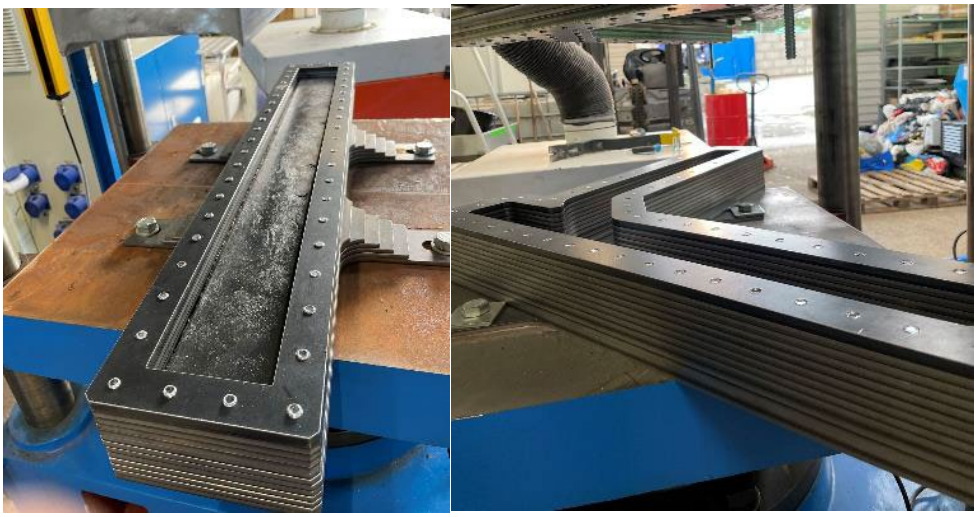

Figure 6: *Mould built up of sheet metal layers, with bar (left) and L-element (right)*

Prototyping

First prototypes are made at the Green Plastic Factory in Almere, using mixed plastics from post-consumer packaging waste. As a first step, the materials are agglomerated into smaller pieces, see figure 8. Next, the agglomerated material is extruded, weighed, pressed into a mould and cooled, see figure 9. After the product is cooled, the finished element is then taken out of the mould elements, see figure 10 for an example of a finished L-element.

Figure 7: *Input material at the Green Plastic Factory: mix plastic packaging waste (left) and agglomerated material (right)*

Figure 8: *Extruded material (left) and pressing L-element (right)*

Figure 9: *Finished L-element (left)*

Assembly

The final product is assembled by screwing the pieces together[9]. The assembly starts with attaching the middle bar, followed by the two outer bars and then the remaining ones. Last, the rounded squares are attached to serve as legs of the bench, see figure 11.

Figure 10: *Assembly of the product*

The final outcome of this support is a first prototype, see figure 12, which can be learned from and used as a base to develop it further.

Figure 11: *Final prototype of assembled product*

"Another successful PE parts production, testing, adjusting and improving day for 'Plastic Waste free Islands' at the Green plastic factory in Almere."

- *Jaap Pattijn, Design Engineer at Searious Business*

[9] A video of the assembly can be found on Youtube: https://www.youtube.com/watch?v=tn2Kz3vifcY

Testing with coloured input material

For the first prototypes of the park bench, an idea emerged to use coloured material input. Colour testing is important for the final concept. When selling the concept, it is desired to show customers and clients that there are colour possibilities. When using a mix of different plastics and colours, the colour outcome will always be dark grey/black. However, if you sort materials based on colour, the are many more possibilities. A first test was done at the Green Plastic Factory using blue bags as colour input, see figure 13.

Figure 12: *Blue bags as input material (left) and agglomerated pieces (right)*

The first results using this colour input can be seen in figure 14. Using colour sorted material input results in each manufactured part to be unique in its appearance. Each part can be made in a different colour.

Figure 13: *Molten material with two colours as input material (left) and finished bar (right)*

The test went well. The colour came out clearly and the first prototypes show that it is possible to produce products with attractive colours (see also the finished product with two black-blue bars in figure 12). However, the consistency of the colour is difficult to predict. If the main colour output is black this is no issue, but with colours the intensity and spread of the colour will differ each time. In addition, the production costs are much higher because of additional (hand) sorting and colour changes during the extrusion step. The philosophy of the Green Plastic Factory is to save as much plastic as possible, so they prefer not to focus on colour sorting by hand. If such colour outcomes are desired, much larger batches have to be processed.

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 Caribbean and the Pacific Islands are currently polluted by a lot of plastic waste. By setting up a local production plant, this plastic can be transformed into new products. A circular park bench is designed to be created out of this waste, which will be placed on the island's beaches, parks and boulevards. The aim is to clearly show that the bench is made of recycled plastic; this has the advantage that there is no need to hide imperfections in the final product. The product stands out due to its design and the choice of materials, which is not a combination seen on the market yet. The concept allows for products to be made from local waste, for local applications. The product's circularity goes beyond the use of recycled materials, as the product is designed for durability and can last up to 50 years. The product can be easily collected after many years of usage and is designed for disassembly. The recyclability allows for the materials to be transformed into new products after usage.

Product (re)design, testing and/or prototyping

The materials used for the manufacturing of this product are of low-quality, which need to be taken into consideration for the design of the product and moulds. Only 'simple' parts can be manufactured, with for example no sharp edges. To manufacture the product, three different moulds are required: bar, L-element and rounded square. The moulds are built up of several sheet metal layers, ensuring them to be less expensive. First prototypes are made at the Green Plastic Factory, using post-consumer mix plastics. This material is agglomerated, extruded, weighed, pressed into a mould and then cooled before the final product is assembled by hand. A test was done with coloured material input, however this requires hand sorting of materials, which is very time consuming.

4.2 Lessons learned

The most important learned lesson during this support is that it is possible to make products of local waste for local applications. Simple product designs allow for the use of any type of plastic. The materials allow for easy manufacturing, due to its mouldability. It is also possible to create coloured products, but this requires hand sorting of colours, which is very time intensive. The moulds can be produced at low prices due to the use of sheet metal layers. The environmental temperature also has to be taken into account during the design phase, as the product may deform

or weaken in higher temperatures. A smaller bench will prevent bending of the bar and 'sagging' of the product.

4.3 What's next

IUCN now owns the moulds and the islands have received the first prototypes made in the Green Plastic Factory. Next steps are for the company to set up a local plant on the islands, organising equipment and a stable power supply, finding volunteers or employees for collecting waste from the beaches and starting first conversations with the local government to ensure the successful application of the concept. Searious Business is now in process of placing a first set-up in Antigua & Barbuda. The product concept designed and developed as part of this project may also be implemented in other regions and countries, and thereby presents opportunities for scaling up this project for Searious Business.

References

SPREP 2018
https://www.sprep.org/attachments/Publications/EMsG/sprep-legislative-review-fiji.pdf

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