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

Case study report – Save Plastics

Good practice of circular economy business models

Case study report – Save Plastics

Good practice of circular economy business models

As part of the TRANSFORM-CE project, several case studies are done to benchmark existing circular economy business models. This document covers the results of the case study conducted at Save Plastics, based in the Netherlands. A total of 20 case studies will be done, with five cases per country (The Netherlands, Germany, Belgium and the United Kingdom).

Date November 2021

Authors Malou van der Vegt, Evert-Jan Velzing

Deliverable WPT3 D2.1 Benchmarking existing circular economy (CE) 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 which researches amongst others (successful applications of) circular business models, barriers, enablers and needs for circularity, and offers in-depth support for the uptake of recycled feedstock by businesses. A core part of the project is to provide advice to businesses on their way to transition towards a circular economy (CE).
In order to help businesses with developing circular business models (CBM's), it is first important to benchmark existing CBM's of companies. This is done by conducting case study projects with 20 selected businesses throughout North-West Europe. The aim is to provide participating businesses with an in-depth analysis of their current situation and business model, to identify opportunities and provide recommendations for facilitating the transition towards a CBM for these and other companies. The case studies also present an unique opportunity to study barriers, enablers and needs for circularity (and recycling) in more detail.

1.2 Company background

Save Plastics has been producing recycled solutions for public spaces for over 30 years. Their ambition is to process tons of plastic waste per year into new products, striving for a circular world. They use (lower quality) mix plastics, which are leftovers from the recycling process. From this, they make products such as park benches, lampposts, jetties and office building facades. Recently, the Green Plastic Factory has been set up, which processes low-quality mix plastics. The plant is part of the TRANSFORM-CE project and aims for a local circular economy by creating products for a certain area from their own local waste. A short overview of Save Plastics is given in table 1.

Table 1: *Overview of company*

Topic	Information
Company name	Save Plastics
Website	www.saveplastics.nl
Country	The Netherlands
Size of company (0-10, 10-200, 200-500, 500+ employees)	0-10
Mission/vision	"Our vision is a circular world, where we use what we already have, where we import less and export less, and where we look for local solutions to local issues."
Product category	Products for public spaces
Production/operational process	Green Plastic factory: IEM, intrusion-extrusion moulding
Used materials	Mix plastics: mostly PE and PP

1.3 Case study process

The case studies are being carried out between September 2020 and December 2022. The case study process is structured in four steps[1], with an iterative approach at the end of each step. The first step (circularity of the business model) aims at creating a general overview of the company, the context and its (circular) business model, to capture how the company creates and delivers value. The second step (circularity in the value chain) involves a circularity assessment of the company and its activities in the value chain. The third step (circularity of operational activities) is focussed on the circularity of the company's operational activities. The last step involves a wrap-up of the results and concludes with the case company's strengths in regards to circularity, an overview of the barriers and enablers for circularity, and opportunities for further enabling circularity. The final result is a case study description, covering the previously established information.

An overview of the case study analysis process is shown in figure 1 on the next page. In order to obtain the results, each of the three steps is divided into four sub steps: 1) desk research and preparation; 2) interview; 3) reporting results; 4) iteration of results. More information about the process and the steps needed for receiving the results can be found in a separate document ('case study methodology') explaining the case study process in more detail. This report is the result of various conversations and interviews with various people working for Save Plastics. Table 2 gives an overview of the interviewed persons for Save Plastics.

Table 2: *Overview of interviewed people*

	Interviewed person	**Function**
Interview 1: Circularity of business model	Robert Huls	General manager
Interview 2: Circularity in the value chain	Robert Huls	General manager
Interview 3: Circularity of operational activities	Stefan Schoegje	Branch manager Green Plastic Factory
Other informants	Bram Peters Jimmy Mulkens	Owner Project manager

[1] We make grateful use of insights and methods derived from previous research, in particular the case study method of R2π (2017, 2019), the work of Circulab (2020) and the Ellen MacArthur Foundation (2017, 2019).

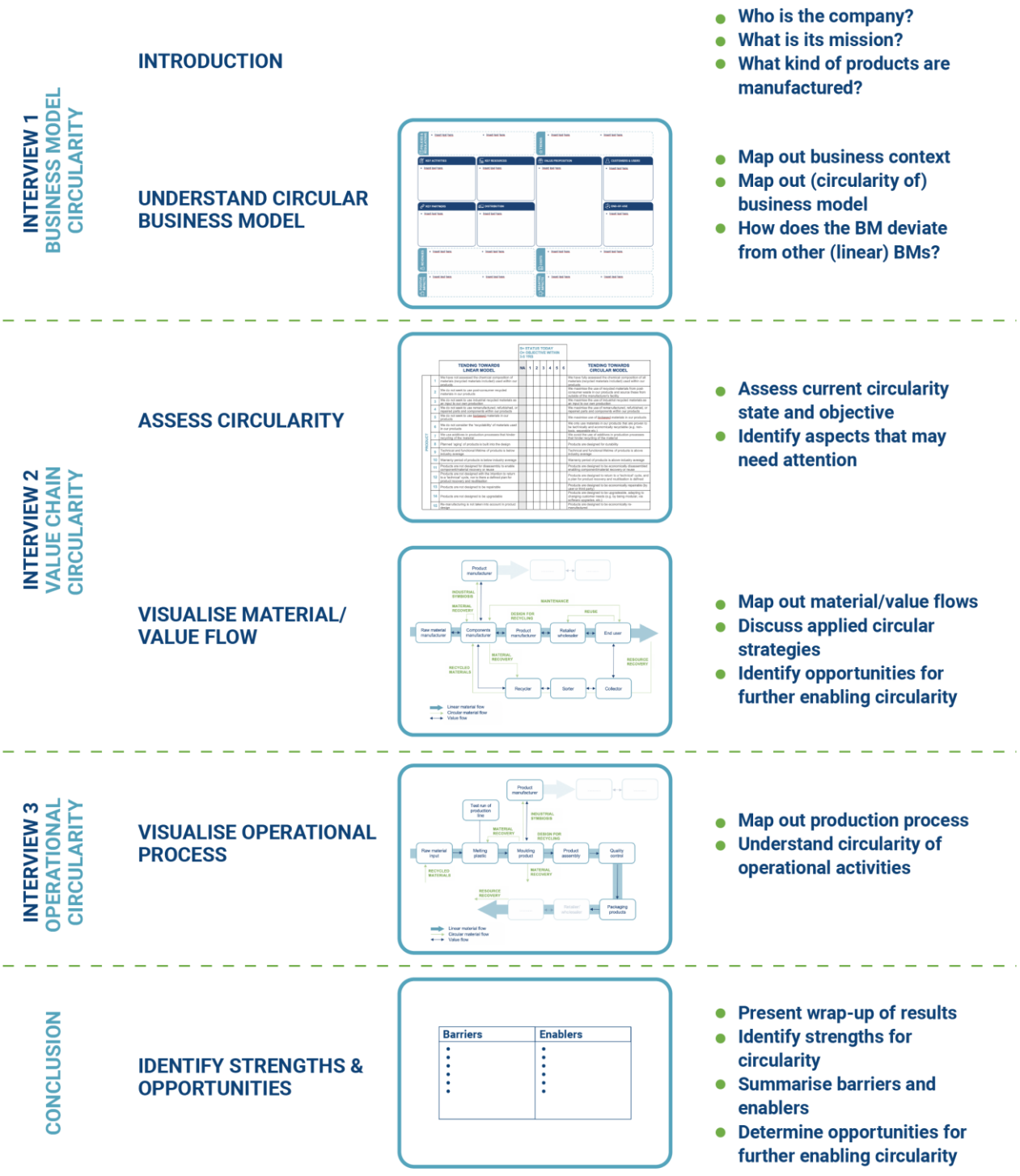

Figure 1: *Overview of case study process*

2. Circularity of business model

The first step aims at creating an overview of the company's business model and the context in which it operates, to capture how the company creates and delivers value (for circularity).

2.1 Circular business model canvas

The circularity of the business model is investigated by using a circular business model canvas (CBMC). This model is created for the purpose of this study and shows how the company creates, delivers and captures value, highlighting circularity aspects of the business. The CBMC of Save Plastics is visible in figure 2 and a description of each element is given below.

Figure 2: *CBMC of Save Plastics*

Value proposition

Save Plastics strives for a circular world, where local solutions are sought for local issues. They see plastic waste not as trash, but as a valuable raw material. With their expertise, they turn recycled plastic into sustainable products for public spaces. Instead of using high-quality homogenous materials streams from the recycling process which are easy to process, Save Plastics takes on a challenge to use mix plastics, which are leftovers from the plastic recycling process. Mix plastics are regarded to be of low quality and are often not wanted by other businesses and thus incinerated. This way they make used plastics valuable again, aiming for a world without plastic waste. The Green Plastic factory shares this vision, and is set up to save plastic waste on a local level. With this plant they are striving for a local circular economy, with local waste processing and local production of new products, for local applications.

"We do not see plastic waste, but a valuable raw material."
- *Bram Peters, owner of Save Plastics*

The use of (low-quality) recycled plastics in products sets Save Plastics apart from competition, allowing for the possibility to create unique products for its customers. They deliver customised products, tailored to the customer's needs. Products only need to be assembled by the customer.

Customers & users

Customers of Save Plastics mainly include municipalities, provinces and regional water authorities. These are the customers who purchase products in large quantities. Examples of governmental organisations they often work with are the municipality of Arnhem, Giethoorn, Hapert, Zevenaar and Almere, and the province of Flevoland and Gelderland.

Through the company's web shop (www.kunststofreus.nl), other businesses, contractors, gardeners and individuals may purchase single products or small amounts of products. Products sold through the web shop are those that are stock products, but could also be products of which its commercial size is no longer interesting for Save Plastics' usual customers (e.g. short planks or posts, or smaller deck boards).

Save Plastic's customers use recycled plastic products to demonstrate their goals and commitment to a circular economy. They make products for public spaces, to contribute to the quality of life in cities. Save plastics furnishes entire parks with benches, picnic sets and lampposts, builds bridges and jetties, installs kilometres of sheeting and makes entire office building facades (see also figure 3 for examples of products). Products can be divided into the following subcategories: posts and planks, sheeting, combi-piles, sheet piles, bridges, benches and picnic sets, purlins, and jetties and decking. Products can be customised according to the customer's wishes. For example, the size or length of products may be adjusted.

Save Plastics has a professional cooperation with its customers and municipalities come back regularly. Together they will think about new concepts to realise. Examples of products Save Plastics is currently working on include: a road brick with the municipality of Doetinchem, three new posts for the municipality of Almere and a facade panel designed by Save Plastics.

Figure 3: *Examples of products made by Save Plastics (bench, jetty, planks, road post, lamppost)*

Key activities

Save Plastics' main goal is to save as much plastic from incineration as possible by finding a suitable purpose. To reach this goal, main activities include the collection of plastic waste and creating product designs out of these waste flows. This also includes acquiring projects, selling of products and providing services needed for product sale. Thus far, most of the production has been outsourced. Recently Save Plastics invested in its own manufacturing site: the Green Plastic Factory. This factory aims for a local circular economy by creating products for a certain area from its own local waste. In this pilot plant, products are made with a new technology called IEM (intrusion-extrusion moulding). This technology is very suitable for processing recycled plastic materials from low quality, allowing for the possibility to process materials with high contaminations.

Where possible, Save Plastics shares its knowledge and commits to local initiatives. Next to these activities, Save Plastics is also working on other projects, regarding education (with their Plastic Fantastic Truck), building a house made of plastic waste, and has several initiatives in other countries. Save Plastics is also actively working on setting up a group of companies around Save Plastics. For each (part of the) market they serve, they have introduced a new company. Examples include the Plastic Fantastic tour to visit schools, and their companies Save Lighting, Save Lodge and Save Home.

Key resources

Save Plastics uses mix plastics as its key resource for making products. These are often leftovers from the recycling process, consisting of multiple different types of plastics. This residual stream is not further filtered because of high costs and low yields. For this reason, mix plastics are often not wanted by other businesses and are therefore usually incinerated. Save Plastics found a solution for this, by using intrusion-extrusion moulding to transform low-quality recycled plastics into new products. Mix plastics come from packaging waste after usage by consumers (post-consumer resin, PCR) and mainly consist of polypropylene (PP) and polyethylene (PE), but may also contain other plastics. Other materials that may be used by Save Plastics come from businesses or include the recycling of Save Plastic's products at end-of-life (EOL). Because of the recycling obligation for recyclers, Save Plastics never pays for any material. The same applies for waste

received from businesses, because its often cheaper for Save Plastics to process material, than to offer it as incineration.

"Often it is cheaper to process low-quality materials by Save Plastics, than to offer it as incineration."
- *Robert Huls, general manager of Save Plastics*

Plastic is an ideal raw material for public spaces, since it is indestructible, does not rot or splinter, can withstand rain and can be made UV resistant. Products made from these materials are durable and are suitable as an alternative to wood.
Whereas production is currently (partly) outsourced, Save Plastics owns its own moulds, which are stored at their German production partner. A sawing machine is located in the industry hall in Arnhem. Another important resource is The Green Plastic factory, a pilot plant set up in Almere, the Netherlands. The machines and used production process are specifically designed to process low-quality mixed plastics.

Key partners
Suez, a sorting installation in the Netherlands, is one of the suppliers of mixed plastic for Save Plastics. They collect and sort high-quality recycled plastics and Save Plastics receives a small fee for accepting the remaining waste. For the Green Plastic Factory, used material comes from the municipality of Almere, sorted by Cirwinn. Next to PCR from sorting installations, Save Plastics also receives waste from businesses. Other key partners include their German based production partner, HAHN, who processes the recycled plastics sourced by Save Plastics into new products. Save Plastics works closely together with its partners on projects, striving for local collaborations towards a circular economy. In collaboration with the municipality of Arnhem, for instance, plastic waste is collected for the production of plastic benches, to be placed in Arnhem's parks spread throughout the city.
Next to this, Save Plastics is also part of the TRANSFORM-CE project, in which they work together with various businesses, municipalities and research institutes across North West Europe to make valuable use of recycled single-use plastics.

Distribution
Products are distributed to Save Plastics customers by truck. Often, this goes via the industrial hall in Arnhem (for product finishing), but on a rare occasion may also be decided to send products directly to the customer. Most products are made of solid plastics, which are heavy and come with high transportation costs. For products ordered through the website, this often comes along with additional costs for the customer, because they are ordered in small amounts with orders under 2000 euros. Products of the Green Plastic Factory a specifically designed for its customers, so no cutting is (yet) needed. Hence, products are directly shipped from Almere to the customer.

End-of-use
Save plastic's products last for over 50 years and can be recycled up to nine times. When products are no longer used, they are taken back by Save Plastics and new solutions are sought for together with the customer. In the future, they want to offer the option to take back other products (not

made by Save Plastics) from organisations. Save Plastics will then recycle these products and materials for an additional fee that covers the costs for reprocessing. Products are currently not repaired, but broken parts may be replaced by new ones.

Costs & revenues

The materials used by Save Plastics are of low value, therefore Save Plastics is paid for using these materials, as municipalities will also have to pay for disposal (incineration) of such low-quality materials. Other revenues come from product sales or subsidies. The latter are essential to cover for costs regarding development and innovation. Based on the various revenues streams, their annual turnover is approximately two million euros per year. They process about 2.5 million kg of plastic a year, with the goal for the Green Plastic factory to process 1500 ton a year. Other costs involve fixed and service costs and personnel.

Policies & regulations

Since products of Save Plastics are meant for outdoor use, there are not many rules or regulations that hinder the application of recycled feedstock. Of course, norms and standards apply, but this is no different from the use of other materials. The recycling obligation of waste separators stimulates the use of low-quality mix plastics, because Save Plastics receives money to process these materials.

Trends

Municipalities are aiming to become circular in 2050, helping with the growing demand of Save Plastics. There are not many other companies that also deliver a total concept like Save Plastics. One competitor (Lankhorst recycling) has similar products, but they are made from industrial waste, rather than post-consumer waste. Wood has been used for hundreds of years and has been extensively tested. Recycled plastic has yet to go through that phase. Municipalities often want personal test reports. It takes effort to convince them about the use of recycled mix plastics. Every municipality is different with regard to trust and demand for recycled plastic products. Products are continuously compared to alternatives made of wood or steel, which are often cheaper. Save Plastics is looking into providing certificates that show savings into CO_2-emissions when using their products.

Moreover, municipalities also have their doubts because of potential micro-plastics. However, most of the cutting work is done in Save Plastic's industry hall, so sewing loss is collected and recycled again. There may still be some insecurities about the effects of microplastics when products are placed in the environment. At the same time, it is also said that the biggest cause for microplastics are from cosmetics, laundry (coming from clothes), paint and tire grinding.

Positive and negative impacts

Save Plastics key positive impact is that they save low-quality mix plastics from being incinerated. Mix plastics are used as an alternative to wood, preventing logging. Negative impacts include CO_2-emmissions and energy during production. Moreover, Save Plastics is not recycling materials into high-quality products and there is downgrading of materials. However, materials will still be suitable as raw material input for Save Plastics in decades.

Within their business operations, Save Plastics sorts materials, offers digital brochures, limits the amount of paper used and looks for options to use electric transportation.

"The best thing, of course, is turning a PET bottle back into a PET bottle, but in many cases the recycling process is not so efficient."

- *Robert Huls, general manager of Save Plastics*

3. Circularity in the value chain

After analysing the company's current (circular) business model, a more detailed circularity assessment of the company and its activities in the value chain is made. The material and value flow map is presented, together with its adopted circular strategies.

3.1 Material and value flow map

The ultimate goal of a CE is for resources to flow in circles, with limited leakage out of the system. To evaluate this, it is important to map and visualise the current flow of materials and value within the company's value chain. The material and value flow map of Save Plastics is presented in figure 4. The value flows (blue) indicate that value is being exchanged between actors, and enables an analysis of the relationships amongst key partners. The circular material flows (green) show where the material comes from, where it goes and how it may return into the cycle.

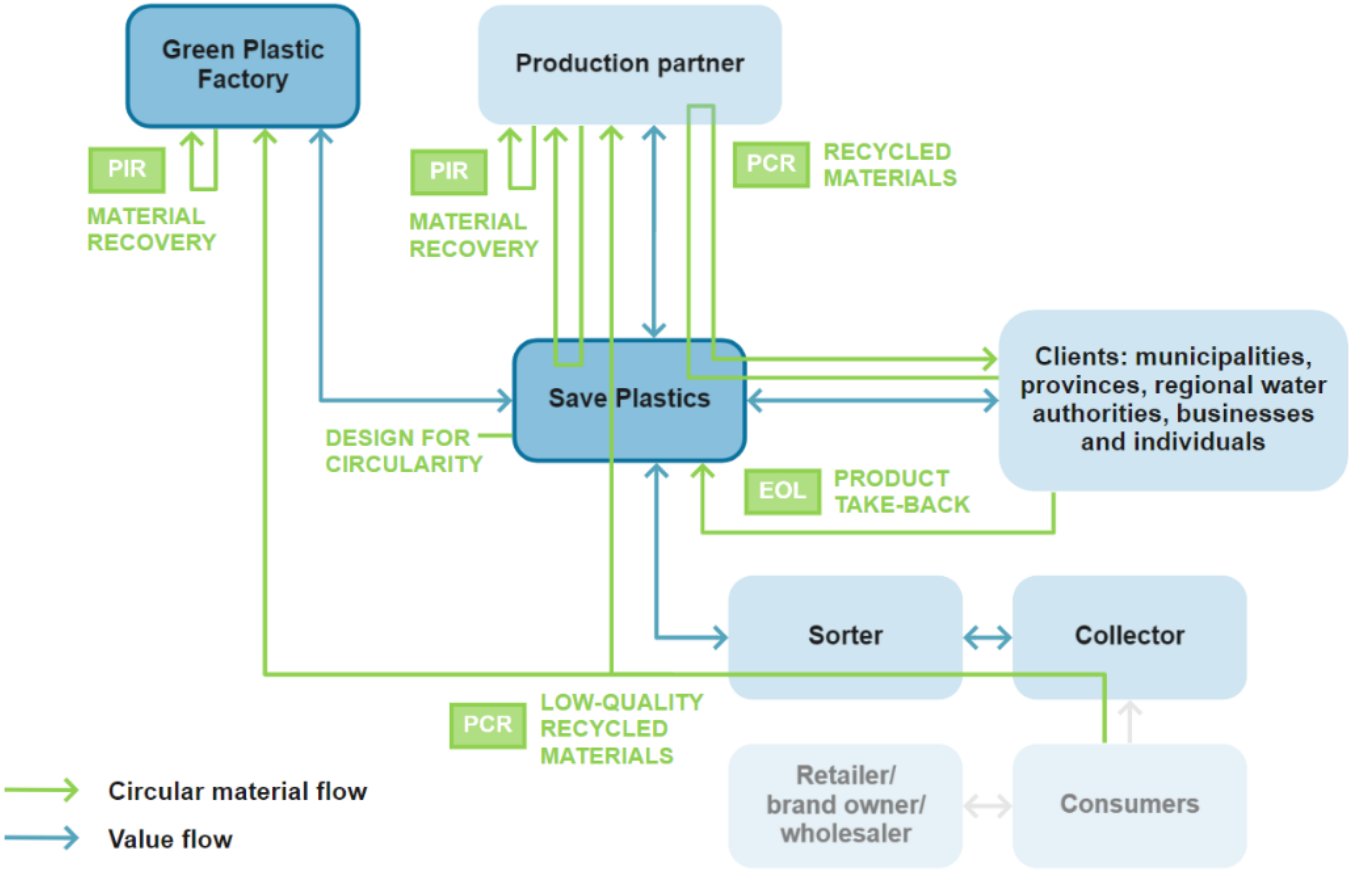

Figure 4: *Material/value flow map of Save Plastics*
(with PCR: post-consumer resin, PIR: post-industrial resin and EOL: end-of-life materials)

3.2 Circular strategies

As shown in figure 4, Save Plastics applies multiple circular strategies: use of *recycled materials*, *material recovery* from cutting product parts, *product take-back* at end-of-life and *designing products for circularity*. Each of the strategies is further explained below.

Recycled materials

All of Save Plastic's products are made of 100% recycled plastic. Recycled materials may come from:

- PCR mix plastics from sorting installations
- PIR waste from production process or product assembly
- EOL waste coming from Save Plastic's products that have reached end-of-life
- PCR waste from businesses

Save Plastics' main input material are mix plastics, which are leftovers from the recycling process that will otherwise be incinerated. This mix flow is about 50% of all plastic packaging waste. It consists of DKR310 (films) and DKR350 (mix plastics, mainly PE and PP). Both streams are largely contaminated because of residuals, laminates, other materials etc.
Save Plastics also offers the option for businesses to supply its own materials (e.g. films collected from packaging materials). Save Plastics will then process these materials into new products, but the business has to buy back these materials in the form of products. Other waste may come from PIR waste from the production process or product assembly, or products returned to Save Plastics at end-of-life.

"If you supply us with plastic, we make something from it. No sorting is needed."
- *Robert Huls, general manager of Save Plastics*

Material recovery

Material recovery may happen at several places along the value chain: during manufacturing, during product cutting in Arnhem or just before installation at the customer site. Most important is that these materials and sewing losses do not end up in nature. During production, there may be industrial cutting waste, but there may also be product failures caused by the mould not filling properly or first pieces when connecting the mould. In Arnhem, products are cut to size, and all waste (e.g. sewing losses) is saved, recycled and reused in new products. Cutting of products happens indoors at Save Plastics, so materials can be captured in a controllable way. Material recovery may also take place at customers, if they decide to cut products again before installing them. Sewing losses will then include pieces of 5-20 cm, and are brought back to Save Plastics in big bags or on pallets.

Product take-back

Save Plastics offers the option to take products back at end-of-life or end-of-use. The customer remains responsible for product disposal, which also means they have to pay for transportation. Save Plastics is looking into the possibility to implement a 1-2% removal fee upon purchase of

products, but this is often the first thing contractors want to eliminate. Options are seen for introducing a deposit, but this will have to be worked out further.
Together with the customer, Save Plastics looks for options to give new purpose to products that have reached end-of-use. An example of refurbished products includes grass tiles which were no longer needed by the customer because of road widening. The products were bought back, cleaned and later resold to another municipality who could really use them.

Design for circularity
Design for circularity by Save Plastics manifests itself in three ways: *design for disassembly, design for recycling* and *design for durability and performance*.

Design for disassembly
Because of the large size, products will always have to be disassembled before being recycled. Products are mechanically connected by means of screws. Broken parts can therefore be easily replaced.

Design for recycling
The products and used materials can be recycled up to nine times. Some products are made of a combination of materials. For their combi pole made of wood (used because of costs) and plastic, a machine is needed to pull off the top part that is made of plastic. For some jetties and bridges, steel reinforced bottom beams are used for strength and stability. But this also limits recyclability as only about 70% of the plastic can be cut out after usage.

Design for durability and performance
Products from Save Plastics last for at least 50 years, which is longer than (wooden) alternatives. They will not rot or splinter, can withstand rain and can be made UV resistant.

4. Circularity of operational activities

After assessing the circularity of the company's activities within its value chain, a more detailed assessment of the circularity of the company's operational activities is done. A visualisation of the operational process is presented, together with its adopted circular strategies.

4.1 Operational process map

To get a better understanding of how the company's operational activities are affected, an overview of the process is made, see figure 5. This includes circular sourcing and design, the production process, and quality assurance and sale of products. Each of the steps will be further explained below.

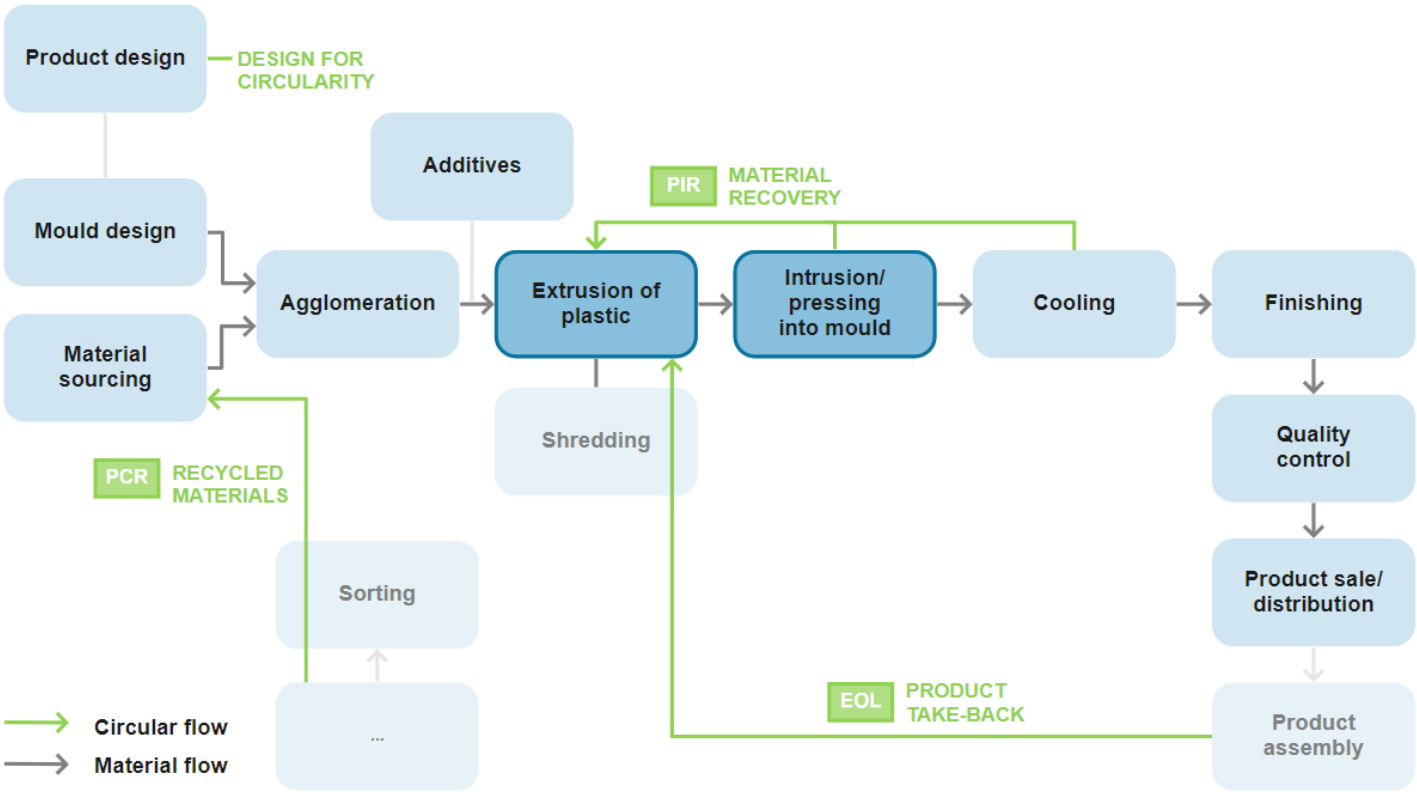

Figure 5: *Operational process map of Save Plastics*
(with PCR: post-consumer resin, PIR: post-industrial resin and EOL: end-of-life materials)

4.2 Circular sourcing and design

The preliminary process consists of material sourcing, additives, product design and mould design.

Material sourcing

Recycled materials from sorters come from the Netherlands, Germany and Denmark. Other materials come from businesses or Save Plastic's products at end-of-life. For the Green Plastic Factory, materials come from the municipality of Almere. The location of the Green Plastic Factory

is next to the sorting installation in Almere, with no transportation needed. The Green Plastic factory aims for a local circular economy. Local in this sense means 'where there is interest'. So wherever there is waste, a factory could be placed. The aim is to place factories where there is application space, so there is less transportation of waste. Though, this also comes with the disadvantage of having to a establish a new facilities, expertise and partners each time. Quality of waste is different everywhere, it is collected and sorted differently etc. This does not mean it is better or worse, but just different. Local sourcing of waste is also more inefficient, because for each factory permits are needed and applying for these takes time. It also means that one person is needed per small factory, rather than the same person being responsible for one large factory.

"Wherever there is waste, the is a possibility for placing a factory."
- *Bram Peters, owner of Save Plastics*

There is little uncertainties about the material. Because material inputs are not washed, there is always some contamination. Save Plastics can deal with pollution and contamination up to 10%. Preferably the material is not wet, but dry so it smells less and is easier to agglomerate.

"The content of each bin is different. Waste is per definition not consistent, while you do want a consistent end product."
- *Stefan Schoegje, branch manager of the Green Plastic Factory, Save Plastics*

Additives

The use of additives varies on a case by case basis, depending on the application. For example, flame retardants are used if there is a risk of fire. This is important for making plastic houses or facade panels. For facade panels it is also of importance that panels are straight, so fibres are added to limit warping. Fibres will also help to reduce shrinkage. If black or brown products are desired, colourant may be added. For black coloured products this is soot, for brown coloured products this is iron oxide. For grey products no additives are needed, since recycled plastic already has a grey colour. The colours also act as UV stabilisers, preventing decolourisation of products due to UV radiation. The use of additives are based on customer wishes, requirements from Save Plastics or if needed to require certifications.

After the first product is made, a feedback loop will take place. The product will be assessed and based on the results it is decided if something needs to be adjusted. This could for example include using more or less additives. If flame retardants are used, aspects to assess products include: the appearance, look and feel of the product, if enough additives are used for the flame retardant to do its job, if products can be still be recycled again etc. More specific material or product tests such as researching tensile strength, bendability etc. is outsourced to other parties.

Product design

At this moment several types of products are being made. Because different types of plastic are used to make the products, it is not possible to work with extreme accuracy, which means that products must always have a minimum thickness of 2 cm. Hence, it is not possible to make very technical or precise products. Products need to be bulky and suitable for outdoors and often

include profiles, posts or planks. Moreover, products from recycled mix plastics are very heavy. For example a 3 m decking board weighs about 25 kg. A wooden decking of the same size is about a third of that weight.
In consultation with the customer, a first draft (manual sketch) is made based on their wishes. Their German partner then makes a working drawing, which goes back to the customer to check dimensions before making the mould. For the Green Plastic Factory, product design is outsourced to an engineering company, which they work closely together with.

Mould design
Products are designed in such a way that they are simple and parts can be easily replaced. Most important during the design phase is to take into account the use of recycled materials from the start. The low-quality mix plastics are heavy and clumsy and experience is needed for designing the moulds. For example, thickness of the product, wall thickness and warping of products need to be taken into account. For each product, moulds are made of different sizes, according to the customer's wishes. A mould can easily cost several thousands of euros, so preference is given to standard sizes. However, compared to moulds of industrial injection moulding processes, the moulds of Save Plastics can be regarded as cheap.
The Green Plastic uses an unique system for building the moulds. Normally, one piece of metal is used and a certain design is milled from the material. In contrast, the moulds for the Green Plastic Factory are built with layers of sheet metal, which are fastened with a bolt. Each layer is laser cut, which makes the mould about ten times cheaper than those used in industrial settings. The lower costs allows them to be more innovative. Because of the use of layers, it may occur that ridges are visible if a draft angle is needed. Such issues do not happen in professional set ups, but customers usually have no problem with it. An example of a mould they have made recently is for a paving stone to be used around lampposts. The mould has an interchangeable core so it can be applied for lampposts with different diameters.

"Without experience with the material, you can never make a successful mould."
- *Stefan Schoegje, branch manager of the Green Plastic Factory, Save Plastics*

4.3 Production process
The production process of Save Plastics is partly outsourced to their German production partner, but the idea for the Green Plastic Factory is to take over the production part. This will ensure that the production process is done internally and locally. This paragraph describes the production process of the Green Plastic Factory. As of this moment, it is still a pilot plant, but it is also scalable to process bigger numbers in the future. Capacity may be adapted to meet the increasing demand. In the Green Plastic Factory, the production process starts with agglomeration, followed by extrusion, intrusion/pressing, cooling and finishing.

Agglomeration
At the Green Plastic Factory, foils are delivered in large batches. The materials are sorted, but not washed. Sometimes there are other (unwanted) products in batches as well, ranging from

deodorants to t-shirts and diapers. This may give problems with material output (e.g. dust cloud from t-shirt), but also safety (e.g. explosion danger from deodorants) and hygiene (e.g. used diapers). The foils are inserted into the agglomerator. Inside is a cylinder chamber, with on the bottom a turntable with two knives. The side walls also have knives, which turn against the bottom knives. This causes friction, resulting in the material being cut and heated at the same time. This process goes on until the material is clotted enough. This process is not timed, but based on feeling. Based on visual appearance, touching, but also hearing is decided when usable plastic 'chunks' are formed. After this, the chunks are extinguished with water, to prevent lumps from being formed. How long this takes differs each time and, depending on the batch, the outcomes differ from dust to chunks of 1 cm. If the process is stopped to late, large lumps will form and the material will stick to the machine. For these lumps to be reused, a shredder is first needed.

"To process low-quality recycled materials, all senses are needed. You need to smell, hear, see and feel. Just don't taste the material."

- *Stefan Schoegje, branch manager of the Green Plastic Factory, Save Plastics*

Extrusion of plastic

The plastic chunks are then inserted into the extruder, together with desired additives. The material goes into a hopper, after which the chunks are melted and pressed forward gradually by means of a rotating screw. The outcome is then a hot plastic mass.

Based on the input material after agglomeration, machine settings may be adjusted. The texture of the chunks can for example be coarser of finer, requiring the temperature of the machine to be warmer or colder. Usually the machine is warmer at the end of the day, so the time needed for the material to pass through also varies. This takes a lot of 'playing' with the machine settings.

"It's continuously testing, tweaking and tuning. To figure out what works and what doesn't."

- *Bram Peters, owner of Save Plastics*

Intrusion/pressing into mould

After extrusion, the molten material is inserted into a mould. There are three ways to shape (extruded) material:

- By means of a die, where molten material is shaped into one direction (continuous).
- With intrusion, quickly injecting molten material into a mould (discontinuous).
- Or a combination of the above, weighing molten material into a pot, transferring this to the mould and then pressing it with certain pressure to be shaped.

The Green Plastic Factory uses the latter, which is called IEM (intrusion-extrusion moulding).

Intrusion-extrusion moulding

IEM technology combines the benefits of both extrusion (extruding materials in one direction) and intrusion (shaping material in a mould), so Save Plastics can successfully apply low-quality recycled materials in new products.

With extrusion the molten material is pressed through a die. The problem here is that the product can only be shaped in one direction and the use of recycled materials will lead to imperfections on the sides. This is prevented by using a mould, such as done with intrusion. But with a normal injection/intrusion process, the material is pressed in one movement, and the process does not have a continuous flow. This may give problems when using recycled materials from low qualities, which will get stuck in the machine because of lower melt flows. Using the continuous flow of extrusion will help to prevent this.
By combining these two technologies, the advantages of both are used, which makes it easier to process recycled materials. This will also allow for processing of low-quality materials with high(er) contaminations. The Green Plastic Factory wants to further develop this technology, going more toward an industrial intrusion process. Since this is as professional process, it also requires a more professional set up. Pressing material is simpler.

Cooling
Cooling of products in the mould takes about five minutes. The extrusion process requires about the same amount of time to gather enough material. If not, machine settings can be adjusted (slower or faster) so it matches cooling time. After cooling the products within the mould, they are placed in between metal plates with pressure. The products continue to cool there, to prevent warping of products.

Finishing
Sometimes products have rough edges that need to be trimmed. If this is required, it happens directly after the product is out of the mould, before further cooling. Because the Green Plastic Factory makes specific products only, no cutting is yet needed. For Save Plastic's products manufactured in Germany, products such as planks or posts can be cut to size. This usually happens in the industry hall in Arnhem. Sewing losses are collected to be recycled.

4.4 Quality assurance and product sale

The last part of the operational process consists of quality control and sale/distribution of the end product.

Quality control
Product quality is always checked at the end. However, desired end quality varies per product or application. For example, for sheet piles a few scratches does not matter, but for a park bench it does. Hence, per product is checked to what extent the product may be 'damaged'.
When products are finished, there is always a certain smell. This comes from contamination and processing, and smells like burnt plastic. Although the smell, it is still save for one's health. Customers usually do not mind the smell, because they know about it and products are used for outdoor applications. Often the smell is gone within half an hour.
There is always a certain expansion of material, with increases of 4-10% on hot days. This brings along certain challenges. For example a facade panel which expands, shrinks, expands etc. will

warp. Save Plastics always informs its customers about such issues in advance. Wood also warps, but warping gives it character. So it does not need to be an issue.

Product sale/distribution

Save Plastics already exists for thirty years and has regular customers. They have enough orders to keep producing, but aim to take on new projects. Customers usually approach Save Plastics and marketing activities are limited. Save Plastics lobbies at high levels in politics. They then go to the purchasing department and take one of the organisation's purchasers outdoors to show examples of what products they can make, and to share the experiences of other customers. Because policy makers and purchasers are often not on the same page, this process can take some time. It may take five years to set up the entire project and get everyone on board.

Although Save Plastics does not experience any problems acquiring customers, they see a challenge in convincing Municipal officials. Governmental employees may have their doubts about Save Plastic's products. Hence, it is important that everyone in the organisation knows the application possibilities of products. Wood has been used for hundreds of years and has been extensively tested. Customers know what it can do. Recycled plastic has yet to go through that phase. For this reason, municipalities often want personal test reports. That takes a lot of effort to convince. Every municipality is also different with regard to the trust and demand for recycled products.

Products from the Green Plastic Factory are directly distributed to customers. Products manufactured in Germany often go via the industry hall in Arnhem, because they have a large sawmill to cut products to size. Separate parts are shipped to the customer, who then has to assemble products on site. If, for example, a bench is assembled in Arnhem, transportation will become difficult and products take more space.

5. Conclusion and recommendations

Based on the outputs derived from all three interviews with Save Plastics, strengths of the business model and operational process in regards to circularity are identified, barriers and enablers for circularity are summarised, and opportunities for circularity are described.

5.1 Strengths for circularity

Business model

When plastic materials are recycled, there is often a 'leftover' stream of mixed plastic waste. Because of the low quality of these materials, they are often not used by companies, so they end up being incinerated. This is where Save Plastics steps in, giving value to low-quality mix plastics by turning them into new products. Recently, the Green Plastic Factory has been set up, which processes low-quality mix plastics. The plant aims for a local circular economy by creating products for a certain area from its own local waste.

Save Plastics strives for a circular world, where local solutions are sought for local issues. They deliver customised products, tailored to the customer's needs. Because of the recycling obligation for recyclers, Save Plastics never pays for any material. The company receives a small fee for accepting the remaining waste. The same applies for waste received from businesses, because it is often cheaper for Save Plastics to process materials, rather than to offer it as incineration.

Save plastic's products are continuously compared to alternatives made of wood or steel, which are often cheaper. This takes a lot of convincing. Municipalities also have their doubts because of potential micro-plastics. However, most of the assembly work is done in Save Plastic's industry hall, so sewing loss is collected and recycled again.

Circular strategies in the value chain

Save Plastics' main input material are mix plastics, which are leftovers from the recycling process that will otherwise be incinerated. This comes from packaging waste after usage by consumers (PCR) and mainly consist of PP and PE, but may also contain other plastics. Save Plastics also offers the option for businesses to supply its own materials (e.g. films collected from packaging materials). Save Plastics will then process these materials into new products, but the company has to buy back these materials in the form of products. Other waste may come from post-industrial waste (PIR) from the production process or product assembly, or products returned to Save Plastics at end-of-life.

Plastic is an ideal raw material for public spaces, since it is indestructible, does not rot or splinter, can withstand rain and can be made UV resistant. Products made from these materials are durable and are suitable as an alternative to wood. Save plastic's products last for over 50 years and can be recycled up to nine times. When products are no longer used, they are brought back to Save Plastics and new solutions are sought for together with the customer.

Operational process

The production process of Save Plastics is partly outsourced to their German production partner, but the idea for the Green Plastic Factory is to take over the production part. This will ensure that the production process is done internally and more locally.

Used materials come from the municipality of Almere, with the sorting installation located next to the plant. Because material inputs are not washed, there is always some contamination. The used technology (IEM, intrusion-extrusion moulding) is very suitable for processing recycled plastic materials from low quality, allowing for the possibility to process materials with high contaminations, up to 10%. The collected foils are inserted into the agglomerator, with friction causing the material to be cut and heated at the same time. This causes 'chunks' of plastic to form. The chunks then go into a hopper, after which the chunks are melted and pressed forward gradually by means of a rotating screw. The outcome is then a hot plastic mass, which is weighed in a pot. Next, the molten material is transferred to the mould and pressed to be shaped. The product is cooled in the mould for five minutes, after which the product is placed between metal plates to cool down further and prevent warping.
Products are designed in such a way that they are simple and parts can be easily replaced. Because of the low quality of materials it is not possible to work with extreme accuracy. Experience is needed for designing the moulds. For example, thickness of the product, wall thickness and warping of products need to be taken into account. The moulds for the Green Plastic Factory are built with layers of sheet metal. Each layer is laser cut, which makes the mould about ten times cheaper than those used in industrial settings. Moulds can also be designed to allow adjustments for variable sizes, e.g. a mould with an interchangeable core to allow for different diameters.

5.2 Barriers and enablers for circularity

To ensure circularity for Save Plastics and its value chain, several barriers and enablers can be pointed out. The biggest barrier for Save Plastics is to create a sales market. Although most are super enthusiastic, it also requires mindset changes from purchasers. Recycled plastic products are more expensive, but also more durable. The biggest enabler they see is being transparent regarding origin, production, design etc. Customers are therefore always informed about possible problems such as smell or warping. This way, more support for the use of recycled materials is created. Other barriers and enablers have been mentioned and explained before and are summarised in table 3 below.

Table 3: *Barriers and enablers for enabling circularity at Save Plastics*

Barriers	Enablers
• Creating a sales market • Mindset changes • Customers ask for test reports • Recycled plastic is continuously compared to alternatives from wood or steel (which are cheaper) • More expensive products (for customers) • Doubts about micro-plastics • No recycling into high-quality products, downgrading of materials	• Saving low-quality materials from incineration • Local solutions for local issues • Seeing waste as a valuable material • Education regarding plastic waste and circularity • Less rules and regulations for outdoor use • Recycling obligation of waste sorters • Receiving money for accepting waste

• If combination of materials is used, recyclability is lower • Quality of waste is different everywhere • Local sourcing of waste is more inefficient (permits are needed for each factory) • More people needed (one person per factory) • Heavy products • Minimum thickness of 2cm • Policy makers and purchasers not on same page	• Aim of municipalities to become circular in 2050 • Durable products, last for over 50 years • Preventing logging (when using wood) • Materials can be recycled up to nine times • Saving sewing losses for recycling • Offering option to take back products • Contamination up to 10% possible • Moulds made with layers of sheet metal • Interchangeable core of moulds • IEM for processing low-quality materials • Informing customers about issues such as smell, warping etc. • Being transparent about origin, production, design etc.

5.3 Opportunities for circularity

Although Save Plastics has been using recycled materials as input for products for over 30 years, there a still some opportunities to further enhance circularity of Save Plastic's products. The company also realises this and is exploring options at for products at end-of-use.

Access

A big opportunity is seen to offer products in subscription form. This means *access* to a product is provided, and Save Plastics remains responsible for product maintenance, repair and collecting products at end-of-life. Municipalities often have a certain budget. When products will be offered in a subscription form, a monthly fee will be charged, which makes it easier for customers to free up money. Save Plastics will then receive monthly payments and is looking for a way to cover investments. This possibility is high on the company's agenda and they are further exploring opportunities to implement this.

Repair and maintenance

Save Plastic's products last for over 50 years and may be recycled up to nine times. However, it may sometimes be the case that a certain part gets damaged or brakes. Save Plastics offers single parts as a replacement, but options for this strategy could be further explored. Whether as part of the above described subscription form or not.

Refurbish

Products of Save Plastics can be returned to the company at end-of-life to be recycled. However, some of the products are still (partly) usable and can be given a new purpose. Hence, it will be valuable to explore options for products at end-of-use. This may for example include options to give products a new purpose. Together with the customer, Save Plastics looks for new application

options. An example of refurbished products includes grass tiles which were no longer needed by the customer because of road widening. The products were bought back, cleaned and later resold to another municipality who could really use them. Such opportunities could be further explored and Save Plastics is actively working on this together with its customers.

Local circular economy

Next to circular strategies, opportunities are also seen to further enhance a local circular economy. To reach this goal, the Green Plastic Factory has been set up to process local waste for local applications. This will save transportation operations, costs and reduce CO_2-emmissions. Save Plastics is therefore actively looking into more opportunities to work on a local level and stimulate the implementation of a local circular economy.

References

Circulab. (2020). *Circular Canvas: The tool to design regenerative business models.* Retrieved from: https://circulab.com/toolbox-circular-economy/circular-canvas-regenerative-business-models/

Ellen MacArthur Foundation. (2017). *The circular economy in detail.* Retrieved from: https://www.ellenmacarthurfoundation.org/explore/the-circular-economy-in-detail

Ellen MacArthur Foundation. (2019). *Circulytics – measuring circularity.* Retrieved from: https://www.ellenmacarthurfoundation.org/resources/apply/circulytics-measuring-circularity

R2π. (2017). *Circular Economy Business Model Case Studies: Introduction and Methodology.* Retrieved from http://www.r2piproject.eu/wp-content/uploads/2018/08/R2Pi-D3-35775-63432.2a-Case-Study-Methodology_v1.0.pdf

R2π. (2019). *Methods and tools.* Retrieved from http://r2piproject.eu/circularguidelines/methods-tools/

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 pilot plants will be set up, one in Almere (NL) and one in the UK. The plants will make use of two innovative technologies – intrusion-extrusion moulding (IEM) and additive manufacturing (AM) – to turn plastic waste into recycled feedstock and new products.

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
Viridor Waste Management Limited

Countries
UK | BE | NL | DE

Timeline
2019-2023

www.nweurope.eu/transform-ce