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# A Business Model for IEM Plant Replication

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**This report is a circular economy business model for a 2000 tonne commercial intrusion extrusion moulding plant. It uses thin film waste plastic to produce durable products, with a lifespan up to 50 years.**

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**List of Abbreviations/Acronyms**

| | |
|---|---|
| AI | Artificial Intelligence |
| AM | Additive Manufacturing |
| C&I | Commerce and Industry |
| CE | Circular Economy |
| DIY | Do It Yourself |
| EfW | Energy from Waste |
| EPRS | Extended Producer Responsibility Schemes |
| eq. | equivalent |
| GHG | Greenhouse Gasses |
| HDPE | High Density Polyethylene |
| HWRS | Household Waste Recycling Centre |
| IEM | Intrusion Extrusion Moulding |
| Kt | kilo tonnes, 1000 tonnes |
| LDPE | Low Density Polyethylene |
| MIR | Mid-range Infra-red |
| MRF | Material Recovery Facility |
| MSW | Municipal Solid Waste |
| Mt/a | Million Tonnes per annum |
| NGOs | Non-Government Organisations |
| NWE | Northwest Europe |
| PAYT | pay-as-you-throw |
| PET | Polyethylene Terephthalate |
| PMC | Plastic, Metal and Drinks cartons (Belgium) |
| PMD | Plastic, Metal and Drinks cartons (The Netherlands) |
| PP | Polypropylene |
| PRF | Plastic Recovery Facilities |
| PPF | Plastic processing facility |
| PTT | Pots, Tubs and Trays |
| RFID tag | Radio Frequency Identification tag |
| RDF | Refuse Derived Fuel |
| RCV | Refuse collection vehicle |
| SPI | Society of Plastics Industry |
| SUP | Single Use Plastic |
| WfH | Waste from Households |

## 1. Executive Summary

TRANSFORM-CE is an Interreg NW Europe funded project focused on transforming single-use plastic waste into valuable new products for a circular economy. To this end, two innovative recycling technologies were employed: Additive Manufacturing (AM) and Intrusion-Extrusion Moulding (IEM). This report sets out the business model for the IEM process. It begins by looking at the pilot project that produces 150 tonnes of products per annum from 100% recycled plastic. It then looks at an upscaled plant that can produce 2000 tonnes of products per annum by 2028. Following on from the success of the commercial production facility, by 2033 there should be multiple 2000 tonne output plants across Europe.

Save Plastics strives for a circular world, where local solutions are sought for local issues. Plastic waste is not seen as residual waste, 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 material streams from the recycling process, which are easy to process, Save Plastics takes on the challenge to use post-consumer mix thin films from packaging. Thin films mix plastics are regarded to be of the lowest quality and are often not wanted by other businesses and thus incinerated. This way, they make used plastics valuable again, aiming for a circular world without plastic waste. The Green Plastic factory shares this vision, and is set up to upcycle 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.

The use of 100% post-consumer thin films plastics in products sets Save Plastics apart from their 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.  Most of the feedstock will be from a MRF, therefore, the most strategic partner to secure feedstock for the IEM business, is the local waste management company. However, if their licence is lost, this alliance can evaporate. Therefore, it is very important to have the local municipality as a strong partner. Further to this, given that local municipalities can change political affiliations, it is important that IEM manufacturing becomes part of central government sustainability strategy.  This will secure a long term stainable supply chain and therefore the viability of the IEM industry.

While the initial setup cost is €1M, the potential to add value to a negative valued waste stream into a sales value of €1,500 to €1,800 per tonne, and with a focus of creating projects rather than products, the IEM business can be very profitable.

## 2. Introduction

### 2.1 The background to this project

Single use plastic (SUP) causes enormous pollution in our environment. Each year 8 Mt of SUP leaks into our oceans ending up as microplastics affecting our ecosystems (European Commission, 2021). Northwest Europe (NWE) generates the biggest source of SUP (40% of Europe). The EU generates 27 Mt per year of waste plastic, of which 31% is recycled, 41% is sent for energy from waste (EfW) and 27% is landfilled. This is a loss of valuable resources to the European economy. The challenge is to reduce this 68% loss of processed plastic, by upcycling it from end-of-life waste into durable long-life products.

In 2019 EU plastic production was 53.6 Mt with 29.5 Mt collected for recycling, of which only 10.1 Mt was actually recycled and only 4.6 Mt were used in new plastic products (Plastics Europe, 2020). The rest was exported. The EU is reliant on imports of virgin plastic and there is a huge opportunity to valorise low and high grade recycled SUP as an alternative to virgin plastic. The EU has set an ambitious 2025 recycling target of 65% for packaging materials, which includes SUP, with an increase to 70% by 2030. Existing lack of infrastructure capacity and viable links to secondary material markets across NWE, forces pre-segregated and mixed waste plastics into landfill and or energy-from-waste (EfW) plants. This approach is not resource efficient, will not enable EU recycling targets to be achieved and clearly does not promote a circular economy (CM) approach. There are real environmental and resource security issues, but currently NWE lacks the economic incentives to solve them.

The plastic import ban to China in 2018, meant the closure of a huge market for the export of European plastics for recycling. With this reduction in the offtake market, this created a reduction in the export demand for the waste plastics, while at the same time the supply of waste plastics continues to go up. In response, EU plastic is being stockpiled and higher levels of SUP are now being sent to energy from waste (EfW) plants and landfill. This is an economic loss to the EU and reinforces the wasteful linear economic model of ‘use once and discard’. The EU Packaging Waste Directive (EU Commision, 1994) and Extended Producer Responsibility (EPR) policy, aims to reduce plastic production and make manufacturers more responsible for the waste they produce. Therefore, there is urgency for NWE to develop its own plastic recycling economy, to reduce reliance on import markets, to repurpose, to revalue existing SUP waste and to upcycle, while at the same time diverting valuable plastic away from EfW and landfill.

Since it is technologically feasible to segregate, re-engineer and repurpose SUP, one of the pilot projects of the TRANSFORM-CE is the Green Plastic factory of Save Plastics in Almere the Netherlands. It focuses on the repurposing of low-grade post-consumer single use plastic packaging waste, that is within the municipal waste system. NWE is a region of mixed economy, with variable levels of wealth and employment. Its consumers produce significant quantities of plastic waste, in part due to affluent and urban lifestyles. The region contains some of the largest urban conurbations in Europe. Several are sufficient to provide consistent and large feedstocks for supplying one or more 2000 t capacity plants just with the low value thin film plastic.

The low valued plastics such as foils i.e., thin packaging films, are moulded into products using intrusion extrusion moulding (IEM) technology. The higher valued plastics i.e., pre-sorted drinks and cleaning bottles, and food trays and containers, are processed into filaments to be used to make additively manufactured (AM) products. AM provides opportunity for integration into complex products, while IEM provides opportunity for simpler single unit designs

The goal for this project is to divert 308.25 t of post-consumer municipal SUP waste over 3 years, which is an estimated reduction in $CO_2$ equivalents of 478 tonnes, (based LCA natureline Save Plastics of 1.3 kg net $CO_2$ reduction per kg plastic diverted), to become feedstock for both AM and IEM. Long-term uptake through scaling up of the technology with industry investment, has the potential to divert approximately 16,000 t in 10 years using the manufacturing processes within this project. Further increases are possible as the TRANSFORM-CE business model is taken up across NWE by the business community.

The unique novelty of the IEM processes developed within the TRANSFORM-CE project is that Save Plastics have developed a recipe that can use, 100% low grade thin film mixed plastic waste, to make products. Other companies may include a small percentage of thin films in their formular (Hahn, 2022), or only use single polymer thin films to produce pellets (Attero, 2022), but most of the feedstocks are higher grade HDPE or LDPE which are rigid plastics.

## 2.2 Focus of this report

This business model for the IEM upcycling plant, is the second report in a series of three, that address the dissemination of the TRANSFORM-CE manufacturing plants across NWE. It looks at the progression from a pilot plant with a capacity of 150 tonnes per year by 2023, to an upgraded plant with larger equipment that has an output of 2000 tonnes per year by 2025, and then at the business model of multiple plants by 2033. It focuses on using a circular economic model with localism. The third report in this series (long term deliverable 2.4) looks at the circular economy business model of an AM plant.

This business model is based on the Business Model Canvas found in Appendix 1 below.

## 3. The value proposition

### 3.1 What is the problem this business model is trying to solve?

To understand the ecological problem of thin film packaging plastics, data from the UK is given as an example. However, the same ecological problem exists not only across Europe but all over the world, yet data is not readily available. SUEZ (2021, p. 9) found that currently only 10-17% of UK local authorities collect some form of plastic film or flexible packaging. They also found that the vast majority of flexible plastic packaging from both households and businesses currently ends up in the residual waste stream that is sent for energy recovery or to landfill. This means that thin film plastics are classified as low-grade waste with very little monetary value, consequently it ends up being burnt to make electricity. The TRANSFORM-CE project looks to upcycle this type of waste with the help of IEM technology. The advantages to society are, the valorisation of a negative valued waste fraction, its upcycling to make durable products that can be initially used for up to 50 years and which can then be ground up and made into new products for up to 10 times. This will save the nine equivalent volumes of virgin plastics. For a potential lifetime of 10 products this locks in the original societal costs for a full use of the original plastic for up to 500 years.

To calculate the possible volume of available thin film plastics for the IEM plant, an estimate from SUEZ (2021) is used. They estimate that the average UK household's consumption per week of flexible plastic is 292 g, of which in the initial stages of a new waste flexible plastics collection scheme, only 56% will be collected. This equates to 164 g of flexible plastic packaging will be collected per household per week. There are approximately 27.8 million households in the UK (ONS, 2021), therefore the amount of flexible plastic that could be available in the UK at a capture rate of 56% will be approximately 4.5 Mt per year, with potential to go up to 8.1 Mt at 100% capture rate. These are huge amounts of plastic that at this time are not being valorised.

### 3.2 What need is an IEM plant fulfilling for its suppliers?

This type of plastic is a burden on local resources to deal with. The local municipality must collect this plastic and a waste management company has to sort and dispose of it. There are monetary costs for this process and in the end if it is not put into the local circular economy, there will be a loss of the value of the plastic. If it has to be sent to a UK landfill the gate fee is £90.00 + VAT per tonne for 2022 (WRAP, 2022). If is sent to an EfW the gate fee in the Netherlands, will be between €100 and €150. Turning local waste into a durable product that stays local is something that appeals to local people and saves costs for the MRF. For parents to take their children to a local playground, where they can play or sit on products that have been made from local waste, gives the community a good-feel-factor. It also shows that the local politicians care about their constituents as well as the environment, and sustainability. Therefore, for a playground that could have been made from hardwood that was imported, but the wood is substituted by plastic from local waste, this is a win-win situation.

### 3.3 What needs is IEM manufacturing fulfilling for society?

One of the problems with making IEM products from 100% recycled plastic is the reluctance of municipalities and consumers to embrace these products. In some instances, there is a worry about ecological damage through micro-plastic leakage, even although there is a good track record going back many years that these products operate within safe limits. There is also the higher cost for an IEM product than for a wooden equivalent. For example, a wooden feather edge garden fence panel will be much cheaper than a plastic one, hence the reluctance to buy the plastic one. However, when the life cycle of the plastic fence is taken into consideration, including the cost and maintenance, plastic works out cheaper and needs less maintenance than a wooden fence. A wooden fence may need to be painted with a preserver every five or so years and will only last perhaps 20 years. Therefore, the cost of a 50-year lifespan plastic fence, should be compared to the cost of two and a half wooden fences, without the maintenance. A further advantage to IEM products is that the material used to make them, i.e., the plastic, can be used again many times, while the wooden fence decays and the wood is finally consumed.

Save Plastics offers the option for local businesses to supply their own materials (e.g., films collected from packaging materials, offcuts from the production process or product assembly). Save Plastics, using its circular economy business model, will then process these materials into new IEM products, which are then sold back to the business.

## 3.4 Circular economy business models

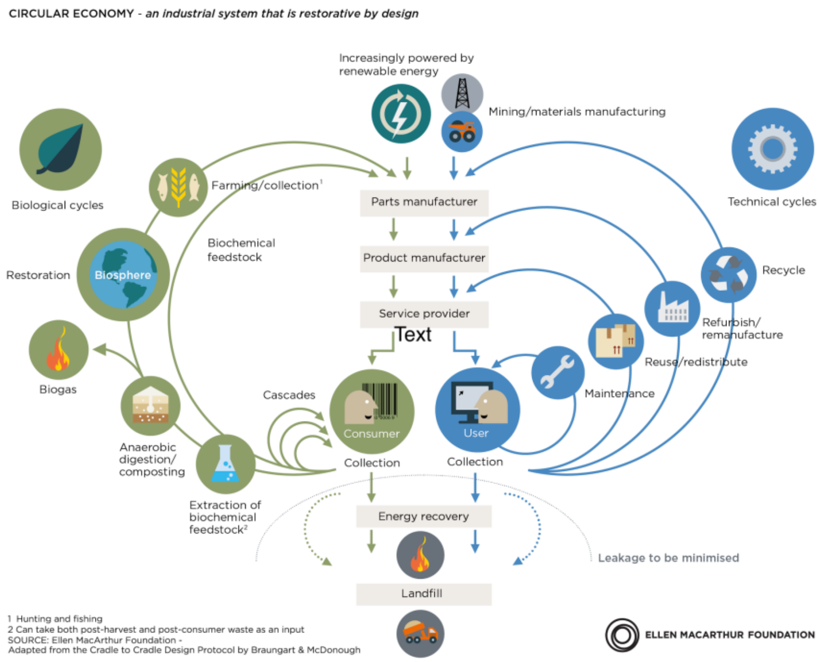



Figure 1 the circular economy butterfly diagram (Ellen MacArthur Foundation, 2023)

The linear economy is shown down the centre of the diagram, manufacture, used and then discard. The goal of the circular economy is to be at the bottom of the right hand side, with plastic products being in constant use. What this shows is that recycling takes a product out of the market and then it is reintroduced as another product. While this is preferable than energy recovery or landfill, it involves energy usage and in many cases a loss of materials in the recycling process.

The circular economy doesn't just look at the materials flow of products throughout their lifetime, but it also looks at the interplay between the manufacturer, the customer and the product. The hardest part of the circular economy is to close the circle. What mechanisms are used to get back the product so that it can be remanufactured into the same or a different product? Furthermore, how will the IEM product be able to be in service to its capacity lifespan, i.e., who and how will it be maintained or repaired if needed?

There are five circular economy business models,

1. Product as a service – instead of the customer buying the product outright, the ownership of the product is retained by the manufacturer. Therefore maintenance, replacement parts and after use disposal are all carried out through the manufacturer.
2. Sharing platform – mainly for the IT sector

3. Circular supplies – usually a company may have a limited number of suppliers that provide the feedstock for the business. However, in the circular economy all customers are the suppliers of their waste as a feedstock to the company. Therefore, in order to keep up the supply of the input materials, the company has to educate their customers about the routes available to them to send the products back. The company has to set up it supply chain, i.e., the route through which customers can send back the products. There is a need to identify the type of product and the materials or composite of the products this can be carried out in a number of ways, via a QR code, RFID tag, or a new plastic identification sign. This identification should allow a unique identification for the product.
4. Product life extension, this is about fixing products so that they can continue to be used for the same purpose that they were made for. A sister project to TRANSFORM-CE is ShaRepair (Print City, 2023),
5. Resource recovery, products are designed to easily be disassembled into their constituent components. This means the design uses interlocking components rather than bonding then together, uses a minimum amount of screws, and no nails.

### 3.5 The circular economy at Save Plastics

Save Plastics, and therefore by extrapolation all manufacturers using their business model, embed circular economy principles at all stages of their production cycle.

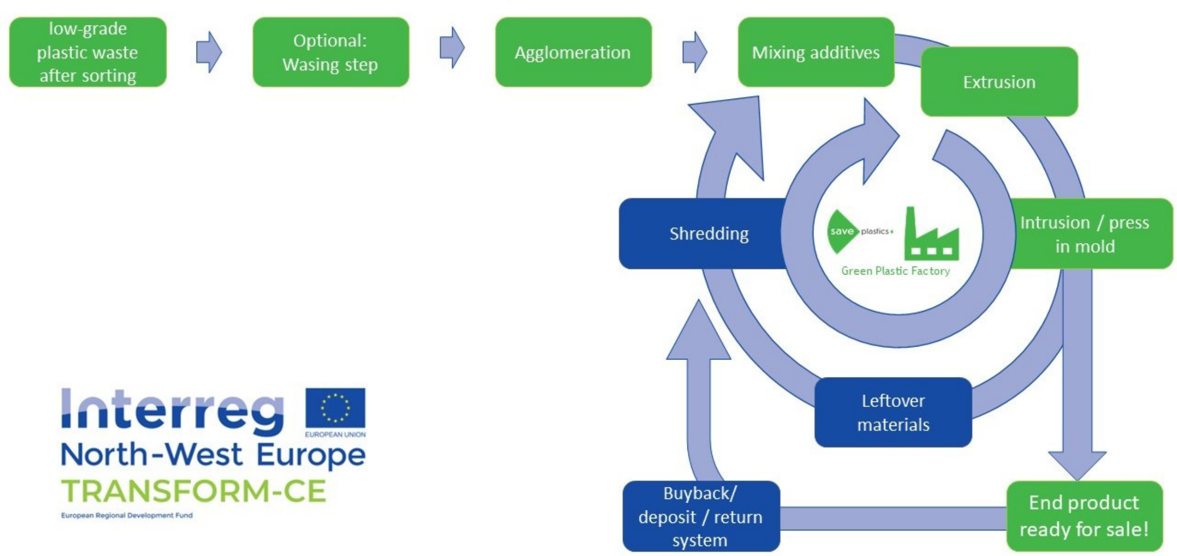



Figure 2 the circular economy model for the Save Plastics Green Plastic Factory

### 3.5.1 Products are designed 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 their 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 removed and replaced. None of the parts are heat welded together. Small products, like the tiles around a street lighting column, are two halves that use an interlocking mechanism with no screws or bolts.

*Design for recycling*

The products and used materials can be recycled up to ten 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 for reuse in a new product.

*Design for durability and performance*

Products from Save Plastics last for up to 50 years, which is longer than (wooden and concrete) alternatives. They will not rot or splinter, can withstand rain and can be made UV resistant. They also don't need painting or wood preservers to elongate their useful lifespan.

### 3.5.2 Material recovery for circularity

Material recovery may happen at several places along the value chain: during manufacturing, during product cutting or just before installation at the customers' site, and at end of life or end of use. Most important is that these material and sawing losses do not end up in nature.

The components at Save Plastics have a standard length and are cut according to the design of the installation. This mean that during build and installation, there are residues that can be 5-20 cm long, as well as the saw dust from the cut. The company has all this waste brought back to the plant for reuse in new products. Sometimes with the initial use of the mould, the mould does not fully fill up, or if something goes wrong with the air outlet valve and the product comes out of the mould not fully formed. Such products can't be sold and are ground up and put back in for extrusion again.

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. However, this can be circumvented by having a deposit scheme which is part of the initial cost of the product.

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. Grass tiles are durable square lattice work that interlock to form a floor framework. They are placed on the ground and grass is sowed in the ground. These are used to provide a mud free and skid free surface at sides of roads that are just earth.  When the local municipality widened the road with a proper surface they were no longer required. They were brought back to Save Plastics where they were cleaned and later resold to be again for their same purpose. This is the best type of circular economy activity. They were initially used as a temporary road surface and now they are being used again in the same capacity but on a different road.

### 3.5.3 Further opportunities for circularity

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

*Access*

A big opportunity to boost sales is envisaged if products are not directly sold but are leased out and paid for by monthly or quarterly subscription. This means *access* to a product is provided, and Save Plastics remains responsible for product maintenance, repair and collecting the products at end-of-life. Municipalities often have a fixed budget.  When products are paid for through a monthly subscription fee, this helps the customers' cash flow situation. However, as Save Plastics will only receive monthly payments, it will be necessary to be able to finance the costs of production and the cash flow of its own business. This business model is high on the company's agenda, and they are exploring opportunities to implement this.

*Repair and maintenance*

Save Plastics' products last approximately 50 years and may be recycled up to ten 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. For example, if the customer is paying a subscription for the product, replacement parts may be free, or if chargeable the replacement fee could be waivered.

*Refurbish*

Save Plastics products can be returned to the company at end-of-use or end-of-life to be recycled. However, some parts of the products are still 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. Like the example of the grass tiles, which were no longer needed by the customer. Such opportunities could be further explored, and Save Plastics is actively working on this together with its customers. This furthers the use of the product and keeps it in the circular economy.

*Local circular economy- Localism*

Circular opportunities are seen to further enhance a local circular economy. Therefore, the IEM plant should be situated close to the availability of feedstock. The outcome will be products for local use made from local plastic waste. For this end the Save Plastics pilot plant was located near the catchment area for its feedstock. To keep things local, a capacity for an IEM plant has been initially fixed at 2000 tonnes per annum. This should save transportation costs and reduce $CO_2$-emissions. In big cities the plants' capacity can be increased in line with circular economy principles. A further selling point is the making of products from local waste which reduced the flow of waste to the local EfW plant or landfill, thus reducing its environmental impact.

## 4. The customers

The IEM process can mass produce simple forms that can be put together to make functional items. Most of these products are for use in an outdoor environment. The advantage of these products is that while being more expensive, for a one to one comparison, they last many times a wooden or concrete equivalent and they are very low maintenance. This means that for the lifetime of the products, up to 50 years, the IEM plastic product will replace multiple equivalent products made from a different material. For example, a featheredge wooden fence, that if not properly maintained, will last 10 to 15 years, while the IEM plastic fence that has a lifespan of 50 years will replace 3 to 5 wooden fences. This is a huge saving in money, time and effort over the 50 year period. For walkways, making concrete groundworks is time consuming and costly, and can be prone to cracking due to ground movement, while a plastic decking solution is easier to install and adjust if the ground moves. There are the added bonuses that the plastic products are low maintenance, should not change colour, do not absorb water and are therefore non-slip, and can be cleaned easily with soapy water.

The first market to a new IEM business to focus on, is the public sector. Within this sector is the parks service, the Environmental Agency, water companies, and local councils. Any project that uses wood or concrete that does not need a high compressive stress pressure, can substitute the wood or concreate for heavy duty IEM plastic products. These include street furniture, playground and parks furniture, fencing, walkways and edgings.

The second target sector is the industrial sector, and here again they are using the same products, e.g., cable and pipe runs, large planters for raised flower beds, bollards, lamp posts, fencing gates etc.

The third sector is the consumer market. All the modular products can be used in gardens e.g., planters, fences, decking, benches, etc.

The timeline begins with the pilot plant whos' customers are municipalities. However, with a 2000 tonne plant in operation by 2028 and the expansion of the business by 2033, all the above customers will be providing income streams for the business.

## 5. Distribution channels - getting products to the customers

There are three modes for installing the IEM products. The first is third party contractors, the second is the manufacturer will have a team of installers, and the third is the user themselves. Much will depend on what the end user product is. For projects like a new playground, or the whole outdoor furniture layout within the grounds of a large public or private building, the manufacturer will be very much involved in the design and installation of the project. However, for consumer end-user products, it will be the consumer themselves or their contractor who will put the products together and install it. If a circular economy model is used, and the maintenance of products is the responsibility of the manufacturer then it will be them or their contractors who will do the installation and maintenance.

The IEM products are much heavier than an ordinary wooden equivalent. These products will come on pallets and will require a truck or van that can operate with pallets. Depending on who will be installing it, will depend on the mode of delivery to the customer. It will be either the contractor or installer who brings it to the installation site, or a third party currier will be used. For DIY installations, products can be picked up or sent by currier. As this manufacturer operates within a circular economy the distance travelled by the products should be minimised, hence the ceiling of 2000 tonnes capacity.

## 6. Growing a customer base

The IEM market is an emerging market that at his time is niche, and compared to conventional products like wood or concrete, is quite a small market. Therefore, initially (by 2028) the growth process has to be manufacturer driven. The pilot project at Save Plastic has already developed the products and has made some installations. These installations will be used by the 2000 tonne plant in their marketing, to showcase their products. The company will make direct sales to gain customers and use past installations as case studies to showcase what they can make. Direct sales will focus on bespoke items individualised just for a particular customer. For example, making for a municipality lampposts and bollards with the city logo or crest on it. Usual advertising and marketing opportunities will be used, and will include a website, through social media and online advertising.

The 2000 tonne a year plant is limited to this size so as to keep within a circular economy model. Therefore, the catchment area for sales will be within a large city or as close as possible to the plant. The amount of wooden fences, decking and pathways edgings used in gardens is very large, and therefore replacing them with plastic products will provide revenues for the company for many years. To grow sales, the colour range, shapes and types of products will have to increase. The moulds for the IEM system are not cheap, but more types will have to be employed to increase sales and maintain a competitive advantage.

After sales customer care is very important and will be a focus to help with product maintenance, customer feedback, and to guide customers through the design, purchase and installation of their projects.

Brand labelling the products with an imprint will help with word of mouth advertising. For example, someone seeing the neighbours garden fence will be able to contact the company if the brand details are on the fence panels.

## 7. Income revenue streams

### 7.1 How will profits be made?

Under the law or regulations across the four regions that this project is relevant, there is a cost to the waste management system for handling and processing a tonne of waste plastic. A MRF will receive money from the Producer Responsibility Schemes, or deposit schemes to offset costs for the recycling the waste. Part of their cost will be the gate fee for the WfE and/or landfill charges. Therefore, the gate fee or disposal fee can become the first income to the IEM manufacturer. Waste management companies who are trying have corporate social responsibility (Lindgreen & Swaen, 2010), would rather pay the gate fee to an IEM business who is doing proper recycling, than to send it to landfill or to be burnt to generate electricity. Therefore, the first income to the IEM business is the value they are paid per tonne to recycle it. This is £90.00 +VAT per tonne for a UK landfill the gate fee in 2022 (WRAP, 2022). If is sent to an EfW the gate fee in the Netherlands, will be between €100 and €150. It is not known how this will develop in the future as charges may change as offtake markets develop.

The IEM plant takes this negative value thin film waste material and upcycles into durable products that are sold for up to €1800 per tonne. If operating at a full production of 2000 tones this is a gross income of €1800 per €3.6 M per annum, plus the conservative gate fee of €100 per tonne adds up to €200,000.

A second stream of income is from the manufacturing sector. The plastic by-products leftover from the manufacturing process, costs the company for disposal. This post-industrial waste plastic is clean and ideal for IEM manufacturing. If a deal can be made with the business to collect or send the waste to an IEM plant at a price more competitive than sending it to a MRF, this is another way to get plastic very cheaply. This will help the manufacture fulfil its corporate social responsibility. Also, the IEM plant can take in waste plastic to make something for its owner. A manufacturer that makes plastic products could send in its waste for the plant to turn into products they need, e.g., garden/ urban furniture.

### 7.2 Value adding to maximise income

The focus of the IEM business should be to take a waste product that at this time has a negative value, as it costs to dispose of it, and add the maximum value to the product. The goal should be to use the plastic as part of a larger or expensive product rather than make generic cheap components that have multiple uses. By adding value to the products, profit can be maximised. For example, if generic fence posts are made, they are only sold at a low price. However, if added to this are fence panels, then what is being sold is a fence rather than the individual items. Similarly, if the plastic is made into the components that when put together are a bungalow, then the value of the plastic is being maximised as now the plastic is part of a house and not just as cheaper paving brinks for a new pathway. The plastic is now sold as a house for the tens or hundreds of thousands of Euros, or Pound, depending on size and location. The goal is to work very closely with the customer to provide a service that includes design manufacture and installation of the products. thus a project is what is sold and not components for the project.

### 7.3 What value is the customer paying for?

For bespoke items the customer is buying a product package that includes, consultancy, design, as well as the installation and maintenance of the product. The plastic products that are made have a lifespan of 50 years. The customer has a dilemma, buy now a durable IEM produced product that will last for 50 years with minimal maintenance, or buy multiple products made from other materials to last the same 50 years, but which will need some maintenance through their useful lifetime? The IEM products can come in Grey, Black, Brown, green and reddish to provide a pleasant and aesthetic wood look, or smooth surface finish.

## 8. key resources required for an IEM plant

The TRANSFORM-CE project was initially a proof of concept project, that by 2023 would have a working pilot plant. The design of the plant is given below in Figure 3. It had a capacity of 150 tonnes per year. Following on from this will be a 2000 tonne per year capacity plant that would be operational by 2025 and by 2028 would be working at full capacity. The long term plan is that by 2033, which is 10 years after the pilot plan phase, there would be multiple 2000 tonne plants across Northwest Europe.

The initial capital to build the plant was a provided by Save Plastics and the TRANSFORM-CE project. The plant was built and was successful in upcycling negative value low grade thin film plastics into durable urban furniture for the local municipality. The pilot plant was labour intensive with little automation.

For an IEM pilot plant to succeed it needs a dedicated sales and marketing executive, a plant manager, a manual labourer, and a back office executive. For the full 2000 tonne plant, initially some and eventually more of these roles will have to be duplicated, and perhaps the hours of operation will have to be made longer, by adding a second or night shift. The machinery needed in the 2000 tonne plant will be more and larger than the pilot plant as will be discussed, including the need for automation.

The main resource required is feedstock. The procurement of a guaranteed long term supply contract with a supply is key for success. From the point of view of an IEM plant it can find suppliers anywhere in the world. However, to keep within the circular economy framework, if one local supplier will not be able to supply the full 2000 tonne of low grade thin film plastic, there may be a need to have more than one contract. Therefore, the location of the plant has to be near the supply of waste plastics, i.e., close to a MRF.

## 8.1 Details of the IEM plant machinery

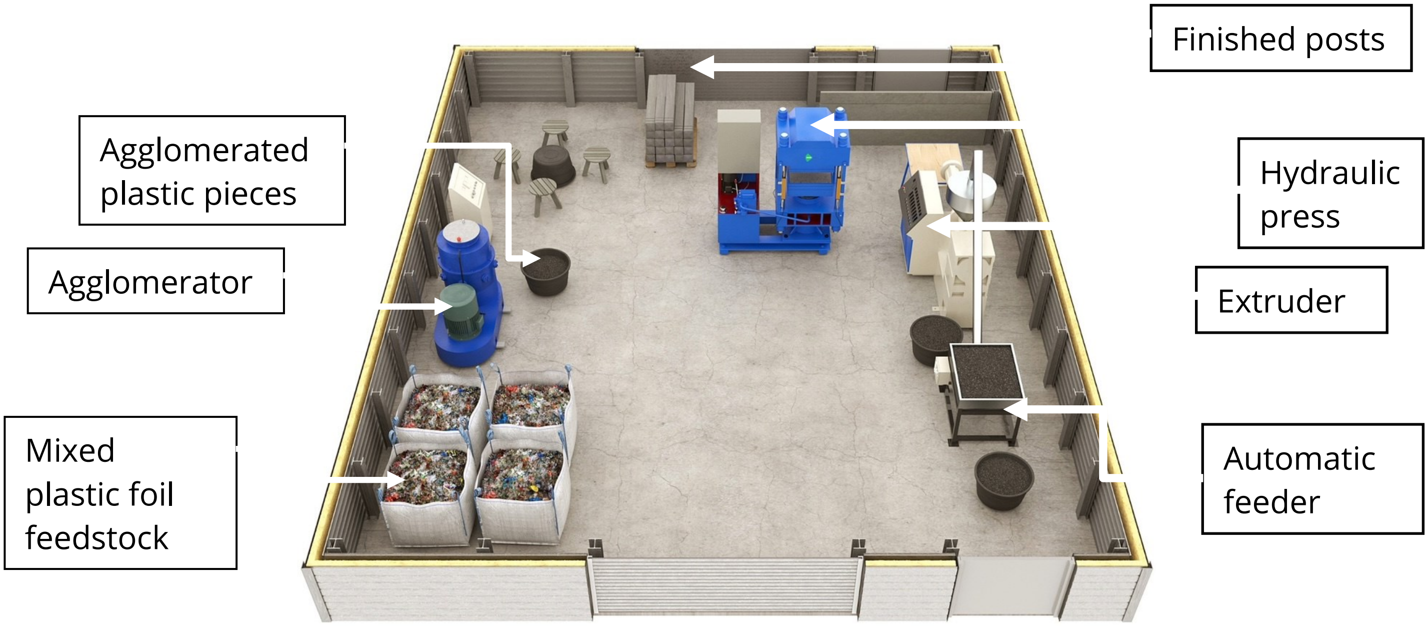



Figure 3 Layout of IEM basic single line plant with 150 tonne per year capacity

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>Agglomerator</td><td>Extruder</td><td>Hydraulic press</td></tr>
<tr><td>

**Technical Details:**

Type: HB 150 Agglomerator

Volume: 150L

Moving knife quantity: 2 pieces

Fixed knife quantity: 6 pieces

Main Motor: type: Y180 4 power: 18.5KW

Rotation speed: 600rmp/m

Outsize: 1700 x 800 x 1500

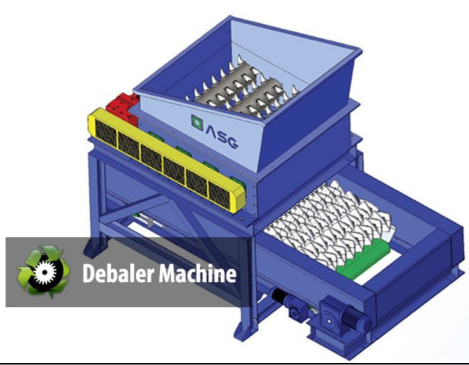
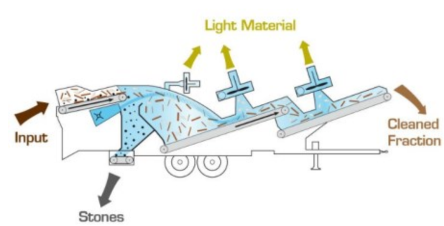
Output: 80kg/h (film)

9. Weight: about 0.8ton

</td><td>

**Technical Details:**

1. Screw diameter 65 mm
2. The proportion of length and diameter of the screw 30:1
3. Screw rotate speed: ≤90 r min
4. Extrusion output: 30-50 Kg /h
5. Barrel heating mode: Cast Aluminium Heater
6. Heating power: 5x 4KW
7. Heating and cooling sections: 5 sections
8. Barrel cooling mode: 5 sections air cooling
9. Cooling power: 0.25 KW
10. Ac motor: 15KW
11. Machine weight: 1500kg
12. Size: 3400x1600x2760

</td><td>
<table>
<tr><th>Model</th><th>XLB-600*600*1/100Ton</th></tr>
<tr><td>mold closing force</td><td>100 ton</td></tr>
<tr><td>Heating Plate size</td><td>600*600mm</td></tr>
<tr><td>Quantity of heating plate</td><td>2 pieces</td></tr>
<tr><td>Cooling plate size</td><td>600*600mm</td></tr>
<tr><td>Quantity of cooling plate</td><td>2 pieces</td></tr>
<tr><td>working layer</td><td>1</td></tr>
<tr><td>Daylight</td><td>200mm</td></tr>
<tr><td>piston diameter</td><td>300mm</td></tr>
<tr><td>Piston stroke</td><td>200mm</td></tr>
<tr><td>Quantity of piston</td><td>1set</td></tr>
<tr><td>Fluid working pressure</td><td>16 Mpa</td></tr>
<tr><td>Max fluid system pressure</td><td>20Mpa</td></tr>
<tr><td>Machine structure</td><td>4 pillar type</td></tr>
<tr><td>Heating</td><td>Electrical heating</td></tr>
<tr><td>Max temperature</td><td>300C</td></tr>
<tr><td>Control method</td><td>PLC +HMI</td></tr>
<tr><td>IR sensor</td><td>2 set</td></tr>
<tr><td>Motor</td><td>2.2 kw</td></tr>
<tr><td>Machine weight</td><td>About 3000 kg</td></tr>
</table>
</td></tr>
<tr><td></td><td>
</td><td>
</td></tr>
<tr><td>Automatic feeder</td><td>De-baler<br><br>petbottlewashingline.com</td><td>Windsifter for the 2000 tonne plant https://power-equip.com/product/komptech-hurrifex-windsifter-separator/</td></tr>
</table>

Between the de-baler, the Windsifter and the agglomerate will be two conveyor belts.

### 8.2 Size of plant

The initial stage of this project was to build and operate a 150 tonne capacity pilot plant by 2023. The second stage is to design and build a 2000 tonne commercial plant by 2028, and then to expand operations with at least one further plant by 2033. The maximum capacity of 2000 tonnes per year was set as this was the limit set so that it stays within the parameters of a circular economy. With a larger than 2000 tonne capacity it is envisioned that the products and perhaps the feedstock will have to travel longer distances, which would increase its carbon footprint. If the market for IEM products exceeds the 2000 tonne yearly volume, then a new plant that is nearer the end users should be built. However, if the plant can stay within circular economy principles, then there is no reason why it cannot be much larger. For example, if it is within a capital city like London or Berlin, where the volume of both feedstock and customers is within reasonable traveling distance, there is no reason that it can't grow beyond the 2000 tonne design capacity to meet demand.

### 8.3 Location site

This project is about implementation a circular economic business model. As part of such a model, the goal is to locate an IEM factory such that the travelling time of both the feedstock and the products to be at a minimum. This implies that the factory should be located as near as possible to the MRF or collection points of the plastic feedstock as well as in the catchment area of where the target clients and installation will be.

The Save Plastic factory is co-located with Cirwinn who is the MRF that supplies the plastic feedstock. Both facilities are in the catchment area of the householders who are consuming the products that the waste plastic comes from. Almere is a city that supplied the pilot plant with 150 tonnes per year. However, with its over 200,000 inhabitants, it is only able to supply 1000 tonne for a plant. This is not enough for a 2000 tonne plant. Therefore, extrapolating this capacity to all cities in the four regions it was found that at least 35 cities have over 400,000 inhabitants. Added to this, are cities with less than 400,000 inhabitants that will grow by 2030. Further plants could be made in capital cities where many millions of people live. This implies that the number 35 for new potential 2000 tonne plants is a rather conservative estimate. Therefore, by 2028 the first 2000 tonne plant should be in operation and by 2033 at least one more should be in operation. For a list of cities that could be potential locations see Appendix 2: below.

### 8.4 Feedstock

The feedstock for the IEM process is post-consumer single use thin film flexible packaging, that is of low-grade plastic. which is at this time only used to generate energy when it is incinerated. Included in this feedstock is food bags, for example crisp bags, that contain a thin layer of aluminium. Save Plastics' main input material are mixed plastics, which were part of a pilot scheme and were collected from approximately 12,000 homers in Almer. This would usually have ended up in the residual waste or be leftovers from the recycling process that would normally be send to EfW and the burnt residuals go into a landfill.

A good feedstock mix ratio for IEM is 70% LDPE, 20% PP and 10% other materials. Ideally it should not contain any PVC, metal or wood pieces, hard plastics, and too much sand or other debris. Small amounts of food residual are not a problem for the IEM processes. The feedstock supplied by Cirwinn consists of DKR310 (films) and DKR350 (mix plastics, mainly LDPE and PP). Both streams are largely contaminated because of residuals, laminates, food, other materials etc.

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

- Post-Consumer Recycled (PCR) mix plastics from sorting installations, i.e., MRFs or MBTs
- Post Industrial Recycled (PIR) waste from production process or product assembly
- End-of-life (EOL) waste coming from Save Plastics' products that have reached EOL
- PCR waste from businesses

### 8.5 Storage

Depending how near the IEM factory is to the MRF, there will be a need to store many tonnes of feedstock. Also, as the factory operates on circular economy principles, all prototypes, mistakes, unsaleable products, will need to be stored until they can be ground up and put back into the extruder to begin a new life as a new product.

### 8.6 Manual or machine pre-sorting

The plastic is collected at kerbside in a specific PMD bag/bin and is taken by Cirwinn to their MRF where all waste PMD fractions are sorted out. This sorting action will be the same at all MRFs the only difference will be in the methodology and machines used to do the sorting. The result of the sorting is a waste fraction that consists of mixed soft/flexible plastic which is of specified content.

Before the feedstock can be agglomerated there is a need to add a sorting process to remove as much of possible of the 15% to 20% contaminants in the feedstock. In the pilot plant the agglomerator is manually loaded, so the operator is easily able to remove any large undesirable non plastic from the waste by hand, before loading it into the agglomerator. However, there is still a percentage of contaminants. This process is slow and will not be feasible within the 2000 tonne plant when in operation by 2025. Therefore, the following equipment will be needed. The first machine is a de-baler, that will open and breakup the tightly packed bale. A conveyor belt with a magnetic separator will be used to remove ferrous metals, and then feed the feedstock into a windshifter machine that uses air separation to remove the heavy contaminants, like wood, sand, earth, nonferrous metals, and glass. The air causes the thin films to rise upwards out of the top of the machine, while to heavies will sink and be removed from the process. From the windshifter machine, the plastic can automatically be batch fed into the agglomerator or fed into large bulk bags for storage. The agglomerator for the 2000 tonne plant will be many time larger than the one in the pilot plant and should have a few sets of spare blads.

### 8.7 Agglomeration

The agglomerator used in the piolet plant is a cauldron shaped machine that has two rotating knifes and 6 stationary knifes. The blades in the agglomerator act like a kitchen blender and chop up and mix the foils. The agglomerator is at this time manually loaded as it requires gradual loading, rather than a whole batch at a time. This cutting motion causes friction that produces heat that heats the plastic up to about 100 C$^{o}$ causing he plastic foils to shrink, plasticise and small pieces clump together. After a few minutes, cold water is sprayed on the hot plastic to stop the batch forming a single large clump, which would be unusable for extrusion. The amount of water is just enough to quickly cool the plastic and evaporates leaving no wastewater problem. The output is irregular shaped very small pieces of mixed plastics. In the agglomerator colourings and fibres can be added to make the final mix ready for the next stage in production.

It was found that the blades ware out quickly when there was aluminium coated plastics in the feedstock. Without any aluminium coated foils, the blads needed sharpening once a month with the aluminium foils the blades needed sharpening every few days (three days was found to be a good length of time). It was found that with the aluminium the agglomeration took 3% longer. For this reason, if aluminium coated plastic can be removed as a contaminant before agglomeration it would help preserve the blades. However, this does not mean that the agglomeration and therefore the end product suffers in any way by having aluminium coated plastic in the feedstock.

The capacity for agglomeration was 50 kgs per hour at the piolet plant, however by 2025 for the 2000 tonne plant, the agglomeration will have to have the capacity of 300 kg per hour. This just means that there will be a need for a larger agglomerator, rather than multiple 50 kgs units. At the time of writing this report, it is not known what effect or if any, aluminium coated plastic will have on the dulling effect on the blades of a very large agglomerator.

## 8.8 Additives

The types of additives added to the plastic include, stabilizers, colorants, plasticizers, fillers and reinforcing fibres, ultraviolet absorbers, antioxidants as well as processing aids including lubricants and flow promoters, (Shamsuyeva & Endres, 2021). 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 carbon black powder is added, and for brown coloured products iron oxide is added. For grey products colourants are usually not needed, since melting together mixed coloured plastic flakes ordinarily produces a grey coloured product. The colours also need UV stabilisers, preventing decolourisation of products due to UV radiation. The use of additives is based on customer wishes, requirements from Save Plastics or if needed to comply with any certifications.

In the piolet plant the additives are added into the mix before the plastic is feed into the extruder.  For the 2000 tonne plant the same methods can be used, or the additives can be added into the extruder while in operation through special holes.

## 8.9 Extrusion – Intrusion

In the piolet plant, the plastic is put into the extrusion hopper, and it is heated up.  The plastic comes out with the constancy of a clay which is weighed off and put into a mould. The mould is then pressed under pressure to form the product, i.e., cladding tiles.

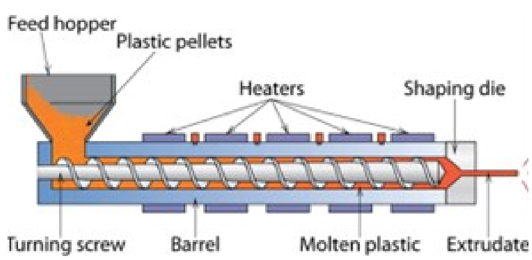



Figure 4 Schematic of an extruder

If the mould is connected to the extruder, (Figure 4) the plastic will be forced directly into the mould under pressure, this is the intrusion processes. In the pilot plant, when the mould is full, it is removed from the extruder and left to cool off, (sometimes up to 4 hours), after which the product can be taken out of the mould. However, in the 2000 tonne plant, circulating water within a heat exchange system will be used to cool the product down so that it can be removed within a few minutes.

### 8.10 Enhancements needed for the 2000 tonne plant

The pilot plant does not have a grinder to regrind large quantities of plastic. For the 2000 tonne plant there will be a need for a grinder to grind up all waste materials. Any products that are received back by way of the circular economy will be ground up before being processed into further iterations of products.

At this time the pieces of plastic that come out of the agglomerator are moist. While this has no significant effect on the processing of the plastic, if the agglomerate was dry, it would improve the performance of the machines and they won't wear out as fast. Therefore, in the future the investment of a drying machine may be helpful, as long as the volumes of agglomerate produced, and the throughput of the manufacturing process is large enough to warrant the investment.

#### 8.10.1 Human power and automation

At this time the scale of operations at Save Plastics is small compared to its final size when it will have the 2000 tonne yearly capacity. Therefore, the visual quality control carries out on the waste plastic is carried out when the plastic is manually loaded into the agglomerator. This visual inspection is to find and manually remove, big pieces of metal or wood. In the future, at full scale, the plant will have some automation of the loading process of the waste into the agglomerator which should speed up the whole process. Also, if the moulds can be automatically removed from the extruder and a new one automatically replaces it, this could speed up the process and therefore the production per day will increase.

## 9. Strategic alliance partnerships

Most of the feedstock will be from a MRF, therefore the most strategic partner for the IEM business is the local waste management company. The waste management companies work under licence from the municipality, usually under a fixed term contract. In Manchester UK, the local waste management licensees have changed hands when the contract came up for renewal. While having a strategic alliance with the licensee is very important to secure a steady supply of feedstock, if the licence is lost this alliance can evaporate. Therefore, there it is very important to have a connection with the local council officers who deal with waste. Having the local municipality as a strong partner, who have the IEM industry in their sustainability goals, will help to secure in the contracts given out to the waste management companies that they must continue to supple the waste for IEM manufacture. Further to this, given that local municipalities can change political affiliations, it is important that IEM manufacturing becomes part of central government sustainability strategy. This will secure the long term viability of the IEM industry.

As the company grows it will seek some strategic connections with local companies through which to sell and be designated as a preferred supplier to their clients. Some example business sectors are, garden centres, building materials suppliers, and landscape architects who design into a project the outdoor furniture.

If alternative suppliers can be found via NGOs or through schools, this will help with the profile of the sustainable message the company is disseminating.

## 10. Key Activities

The main key activities to get the business into operational mode have been discusses so far and consist of the following,

- Full list of the machinery, office equipment, vehicles, and spare parts
- Full design of the plant
- Procurement of capital finance
- Plant setup
- Hiring staff and training
- Securing feedstock partners
- Building customer base
- Customer service and on site maintenance
- Advertising

## 11. Cost structure

As of the writing of this circular economy business plan, a full design with the equipment requires and a full costing is not available. However, based on preliminary work, it is estimated that to buy the equipment and to setup the plant will cost about €1M in capital expenses. This will be depreciated on a straight line basis over 5 years. See Appendix 3 for a breakdown of the preliminary costings.

The fixed costs will include the following

| | | |
|---|---|---|
| Rent | € 80,000 | |
| Electricity | € 144,000 | |
| Wages | € 750,000 | € 974,000 |

The variable expenses will include the following

| | | |
|---|---|---|
| Maintenance | € 44,625 | |
| Insurance | € 25,000 | |
| Cleaning | € 25,000 | |
| IT costs | € 25,000 | |

| | | |
|---|---|---|
| Marketing and selling | € 50,000 | |
| Waste disposal | € 40,000 | € 209,625 |

These numbers are for the Netherlands, however coast will be different in each country and will also change depending on the location of the plant within or outside a town or city.

## 12. Conclusions

The whole IEM business is niche and has a few large businesses across Europe. Therefore, statistics about the market is not available. However, given the amount of wooden, and metal products that could be substituted with solid plastic using IEM technology, there is huge possibilities for expansion of the IEM industry.

The expansion of the IEM market will depend on support from public authorities and consumers creating the demand pull for the products and ingenuity on the part of the IEM manufacturers creating the supply push.

While the initial setup cost is €1M, the potential to add value to a negative valued waste stream into a sales value of €1,500 to €1,800 per tonne, and with a focus of creating projects rather than products, the IEM business can be very profitable.

Most of the feedstock will be from a MRF, therefore the most strategic partner for the IEM business is the local waste management company. While having a strategic alliance with the MRF is very important to secure a steady and sustainable supply chain for feedstock, if the licence is lost this alliance can evaporate. Therefore, there it is very important to have a local municipality as a strong partner, who have the IEM industry in their sustainability goals. Further to this, given that local municipalities can change political affiliations, it is important that IEM manufacturing becomes part of central government sustainability strategy. This will secure the long term viability of the IEM industry.

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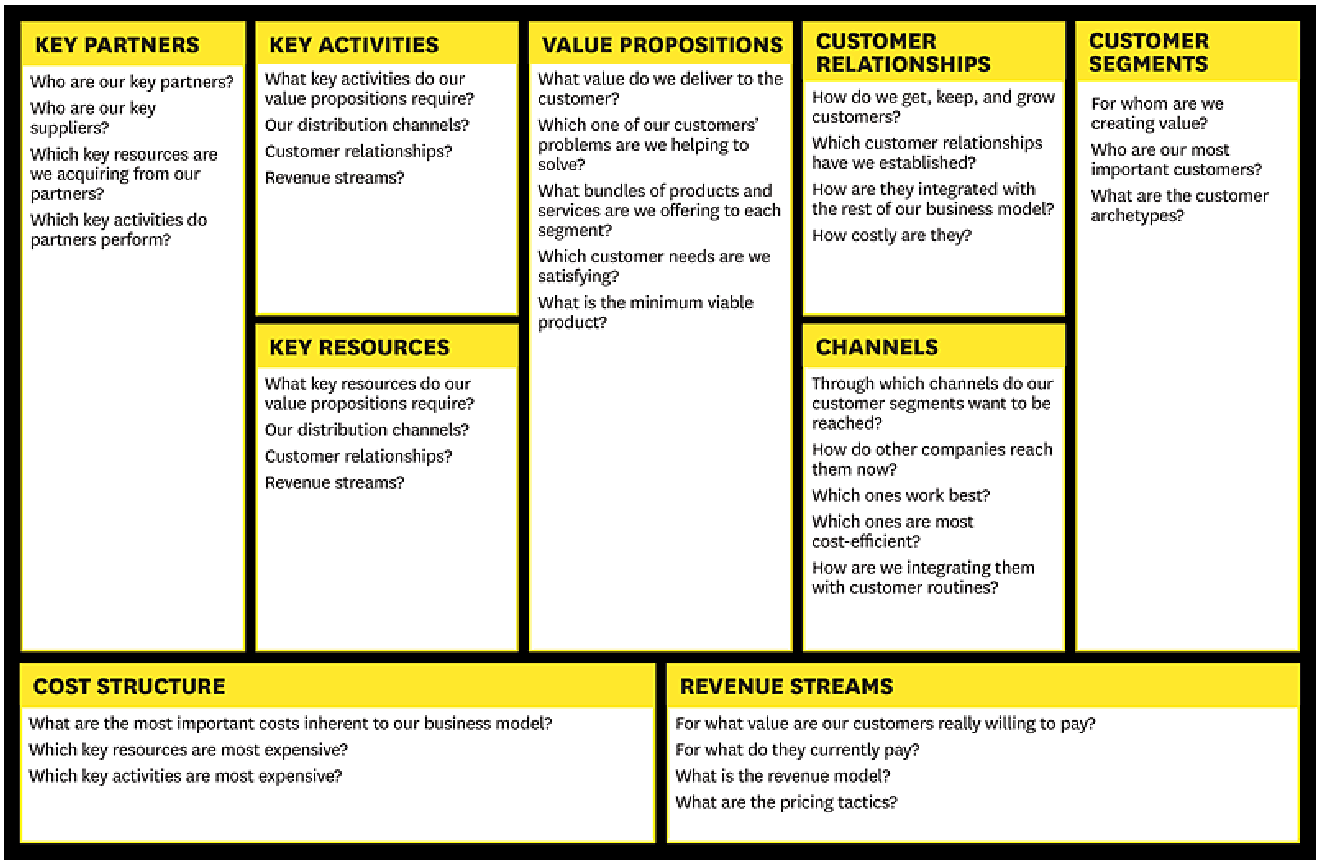
## Appendix 1: Business Model Canvas

Harvard Business school, from https://hbr.org/2013/05/a-better-way-to-think-about-yo



## Appendix 2: Potential location of a 2000 tonne plant only using thin films

Table 1 the largest 36 cities in the UK (The Geographist, 2022)

| City | Population | City | Population | City | Population | City | Population |
|---|---|---|---|---|---|---|---|
| London | 8,907,918 | Leicester | 470,965 | Stoke-on-Trent | 277,051 | Bolton | 202,369 |
| Birmingham | 1,153,717 | Edinburgh | 488,050 | Southampton | 269,231 | Aberdeen | 200,680 |
| Glasgow | 612,040 | Leicester | 470,965 | Derby | 263,933 | Bournemouth | 198,727 |
| Liverpool | 579,256 | Coventry | 369,127 | Portsmouth | 248,479 | Norwich | 195,761 |
| Bristol | 571,922 | Bradford | 361,046 | Brighton | 241,999 | Swindon | 191,314 |
| Manchester | 554,400 | Cardiff | 350,558 | Plymouth | 241,179 | Swansea | 184,436 |
| Sheffield | 544,402 | Belfast | 328,937 | Northampton | 229,815 | Milton Keynes | 184,105 |
| Leeds | 503,388 | Nottingham | 311,823 | Reading | 229,274 | Southend-on-Sea | 183,809 |
| Edinburgh | 488,050 | Kingston upon Hull | 288,671 | Luton | 222,907 | Middlesbrough | 176,991 |
| Leicester | 470,965 | Newcastle upon Tyne | 281,842 | Wolverhampton | 218,255 | | |

Table 2 The largest 37 cities in the Germany (citymayors.com, 2022)

| City | Population | UK City | Population | UK City | Population |
|---|---|---|---|---|---|
| Berlin | 3,275,000 | Dresden | 473,300 | Aachen | 241,300 |
| Hamburg | 1,686,100 | Bochum | 388,100 | Krefeld | 238,000 |
| München | 1,185,400 | Wuppertal | 365,400 | Halle | 237,400 |
| Köln | 965,300 | Bielefeld | 320,900 | Kiel | 229,900 |
| Frankfurt | 648,000 | Bonn | 307,500 | Magdeburg | 224,100 |
| Essen | 588,800 | Mannheim | 306,100 | Oberhausen | 221,700 |
| Dortmund | 587,600 | Karlsruhe | 279,600 | Lübeck | 213,400 |
| Stuttgart | 581,100 | Gelsenkirchen | 276,200 | Freiburg | 206,300 |
| Düsseldorf | 568,900 | Wiesbaden | 269,200 | Hagen | 201,700 |
| Bremen | 527,900 | Münster | 265,900 | | |
| Hannover | 516,300 | Mönchengladbach | 264,400 | | |
| Duisburg | 513,400 | Chemnitz | 255,600 | | |
| Nürnberg | 486,700 | Augsburg | 253,800 | | |
| Leipzig | 486,100 | Braunschweig | 243,700 | | |

Table 3 The largest 18 cities in The Netherlands (worldpopulationreview.com, 2022)

| City | Population | The Netherlands | Population |
|---|---|---|---|
| Amsterdam | 741,636 | Nijmegen | 158,732 |
| Rotterdam | 598,199 | Enschede | 153,655 |

| | | | |
|---|---|---|---|
| The Hague | 474,292 | Haarlem | 147,590 |
| Utrecht | 290,529 | Arnhem | 141,674 |
| Eindhoven | 209,620 | Zaanstad | 140,085 |
| Tilburg | 199,613 | Amersfoort | 139,914 |
| Groningen | 181,194 | Apeldoorn | 136,670 |
| Almere Stad | 176,432 | 's-Hertogenbosch | 134,520 |
| Breda | 167,673 | Hoofddorp | 132,734 |

Table 4 The largest 7 cities in Belgium (geoba.se, 2022)

| Belgium | Population |
|---|---|
| Brussels | 1,019,022 |
| Antwerpen | 459,805 |
| Gent | 231,493 |
| Charleroi | 200,132 |
| Liège | 182,597 |
| Brugge | 116,709 |
| Namur | 106,284 |

## Appendix 3: Setup capital and running costs

# Business case IEM Factory

| | | | |
|---|---|---|---|
| CALCULATION MODEL | | | |

| | | | |
|---|---|---|---|
| | | | |
| Intrusion and extrusion only | | | |
| 2000 tonnes, three shifts | | | |
| Uptime hardware 80% | | | |
| Robotised24/7 | | | |
| Production hall 1000m2 without reprocessing line | | | |
| | | | |
| | Number | Price/piece | |
| debaler machine (5,000 bales/year) | 1 | 50000 | 50000 |
| conveyor belts | meerder | | 12500 |
| windshifter (2000 tons per year) | 1 | 50000 | 50000 |
| agglomerator | 1 | 100000 | 100000 |
| dryer (2000 tons per year) | 1 | 5000 | 5000 |
| Extruder twin screw with Robot | 1 | 500000 | 500000 |
| Consultancy costs | 100 | 175 | 17500 |
| Dies | 10 | 5000 | 50000 |
| Mold device for molds | 1 | 20000 | 20000 |
| Installation costs production hall | 1 | 10000 | 10000 |
| Cooling plant molds / heat exchanger | 1 | 20000 | 20000 |
| Suction, defuming | 1 | 40000 | 40000 |
| Shredder | 1 | 50000 | 50000 |
| Sawing machine | 1 | 10000 | 10000 |
| Small tools | 1 | 5000 | 5000 |
| Forklift truck | 2 | 10000 | 20000 |
| | | | |
| | | | 960000 |
| | | | |
| OPERATING COSTS 24/7 PER YEAR | | | |
| Purchase of granulate in kilograms | 2102400 | 0.4 | 840960 |
| Energy 100KW/hour x 24 hours = | 876000 | 0.09 | 78840 |
| Rental property 1000 m2 | 1000 | 80 | 80000 |
| outdoor stage | 1000 | 45 | 45000 |
| 1 FTE vulwerk | **5** | 45000 | 225000 |
| 1 FTE disposal and packaging | **5** | 45000 | 225000 |
| 1 FTE supervisor (1 head, 2 operators) | **5** | 60000 | 300000 |
| depreciation Extruder | 1 | 100000 | 100000 |
| Depreciation Dies | 10 | 5000 | 50000 |
| Depreciation Shredder | 0.5 | 50000 | 25000 |

| | | | |
|---|---|---|---|
| Depreciation Shredder | 1 | 10000 | 10000 |
| Depreciation sawing machine | 1 | 2000 | 2000 |
| Depreciation Falk lift | 2 | 3000 | 6000 |
| Depreciation conveyor belts | 1 | 2500 | 2500 |
| Depreciation die carousel | 1 | 4000 | 4000 |
| Depreciation debaler | 1 | 10000 | 10000 |
| Windshifter depreciation | 1 | 10000 | 10000 |
| Depreciation dryer | 1 | 1000 | 1000 |
| Maintenance and malfunctions | 1 | 15000 | 15000 |
| Cleaning | 1 | 25000 | 25000 |
| Insurance | 1 | 25000 | 25000 |
| Director Wages | 1 | 100000 | 100000 |
| IT-costa | 1 | 25000 | 25000 |
| selling | 1 | 20000 | 20000 |
| | | | |
| Total Operatingh Costs | | | 2225300 |
| | | | |
| PRODUCT YIELD | | | |
| 300 kg per uur x 24 x 365 x 80% | 2102400 | 1.32 | 2775168 |
| If an organization needs staffing seven days a week, 24 hours a day, the 5-shift schedule is often used. | | | |

If an organization needs staffing seven days a week, 24 hours a day, the 5-shift schedule is often used.
The average working time per employee is approximately 33.6 hours for this shift schedule.

| | | |
|---|---|---|
| Capacity (input) | 2000 | tonnes |
| Interest rate | 5% | % |
| Days/year in operation 24/7 | 300 | days |

## 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