

PRECIOUS PLASTIC

Manual 1.0

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1.0

Introduction

Nice to meet you!



1.1 Precious Plastic

Hey, we are Precious Plastic. Nice one!

We are a bunch of guys (and a few girls here and there) working together to find ways to work with plastic waste. By now plastic has become a threat to entire ecosystems and societies. It is deteriorating our planet and people's lives. It is a problem. A material made to last hundreds of years that is only used for minutes, a fraction of its possible lifespan, and quickly discarded.

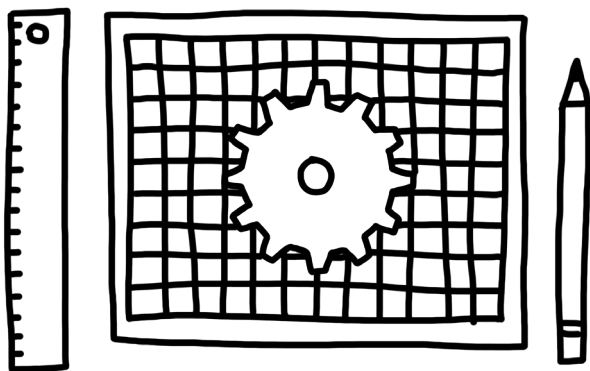
All plastic laying around you is a resource, not waste. A material with great potentials, mostly intact qualities and a sea of opportunities waiting to be discovered. If treated correctly, this resource can become the beginning of something new. For you, society and the planet at large. This resource, laying around everywhere, can become a source of income or an educational tool for your community.

At Precious Plastic we want to show the world the incredible opportunities of plastic waste in order to eliminate plastic pollution, reducing the demand for new virgin plastic and closing its materials loop while creating better livelihoods for people around the world. Precious Plastic is, above all, a cultural tool to change the way society perceives plastic.

We have created machines, documentation, video tutorials, campaigns and a platform to empower people across the planet to start working with plastic waste locally while trying to decentralise and localise plastic

recycling technologies, infrastructures and knowledge by providing open-source designs for machines, moulds and consumer products.

We share everything open source for anyone to benefit from. This means that all the knowledge, know-how, processes, methodologies and tools are available online, for free at all times. This open source philosophy is at the core of the project and shapes most decisions within the team. We believe that collaboration is stronger than competition and that the plastic problem can only be solved collectively.



Precious Plastic machines are built to enable anyone to work with plastic waste and are designed to be as inclusive and accessible as possible. They are made from basic materials, are very affordable and easy to build around the world. Their simplicity allows effective maintenance and easy repair. The machines are also modular so they can be adapted to different contexts and needs.

Precious Plastic is built upon a strong international community of people working together to find solutions to plastic pollution. The community meets online on Dave Hakkens' (our founder) forums to discuss, inspire and help each other find answers to the many questions still open. Discussions range from suggestions and ideas, machine development, creations and research about plastic. If you cannot find the answer to your questions in this booklet, the forum is the place to go.



1.2 The Manuel

This booklet you're holding in your hands should be used as a manual to run a Precious Plastic Workspace- a small scale recycling factory to process plastic waste in meaningful ways. It will help you getting started and should be used as a reference point when lost or stuck with problems. You will find information, know-how, best practices, links, troubleshooting and training material on Precious Plastic processes and machines as well as useful insights about the world of plastic at large.

This publication should be used as a tool to access useful information about plastic, Precious Plastic machines and methodologies. This should not be intended as the only place to direct your search for answers about plastic, it should instead serve as the starting point for further personal research on both the digital and real world.

Good luck !

1.3 Disclaimer

Plastic recycling is a complicated world, closed off behind big walls of corporate interests and intellectual property. This makes it difficult for outsiders or the general public to tap into this. We do our very best to provide the most complete and satisfactory solutions to deal with plastic pollution but we're also aware that we do not have all the answers, yet. We move forward step by step, facing each new challenge as it comes with ever more confidence that a solution to plastic waste is possible. Hopefully, some answers will come from you too.

2.0

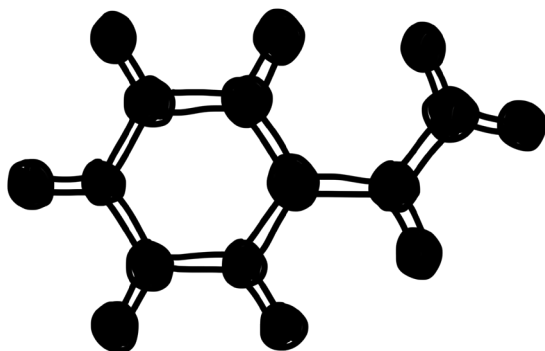
Plastic world

Learn the ins & outs of plastic



2.1 What is plastic

The word plastic is in our mouth day in & day out, but what does it really mean? The word itself is derived from the Greek (plastikos) meaning “capable of being shaped or moulded” and refers to their malleability during manufacture, that allows plastic to be cast, pressed, or extruded into a variety of shapes—like films, fibres, plates, tubes, bottles and much more.



Plastics are synthetic chemicals extracted mainly from petroleum and made of hydrocarbons (chains of hydrogen and carbon atoms). Most plastics are polymers, long molecules made up of many repetitions of a basic molecule called a monomer. This structure makes plastic particularly durable and long lasting.

Due to their relatively low cost, ease of manufacture and versatility, plastics are used in an enormous and expanding range of products, from shampoos (micro beads) to space rockets. Plastic ubiquitousness (it's everywhere!) is causing serious environmental concerns regarding its slow

decomposition rate (recent studies say 500 years) due to its strong bonding molecules. Think it this way, all plastics ever used from your parents and grandparents are still around today and will pollute the planet for another four centuries.

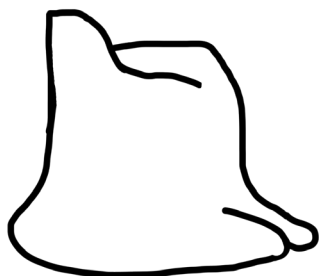
Most plastics contain other organic or inorganic compounds blended in called additives to improve performance or reduce production costs. The amount of additives ranges widely depending on the application and plastic type.

2.2 A bit of history

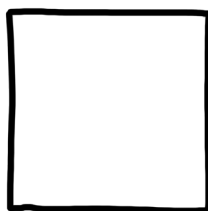
The development of plastics has evolved from natural plastic materials to completely synthetic molecules (e.g., epoxy, PVC). Parkesine (nitrocellulose) is considered the first man-made plastic (1856). After World War I, improvements in chemical technology led to an explosion of new plastics, with mass production beginning in the 1940s and 1950s. World War II led to greater research and development into plastic and the discovery of many new plastic types with different properties and applications. As the war ended, these new plastics made their way into society through a multitude of consumer goods.

2.3 Thermoset & thermoplastics

There are two main categories in the world of plastics: thermoplastics and thermosetting. Thermoplastics are the plastics that can be recycled. Thermoplastics can be melted back into liquid and moulded multiple times. Think of this as butter, butter that can be melted and cooled many times and take various shapes. Thankfully, thermoplastics make up to 90% of global production.



THERMO PLASTIC



THERMO SET

Thermosets can melt and take shape only once; after they have solidified, they stay solid forever. In the thermosetting process, a chemical reaction occurs that is irreversible. Thermoset is similar to bread where once the final state is achieved, any additional heat would lead to burning. No recycling is possible for this plastic. Bummer!

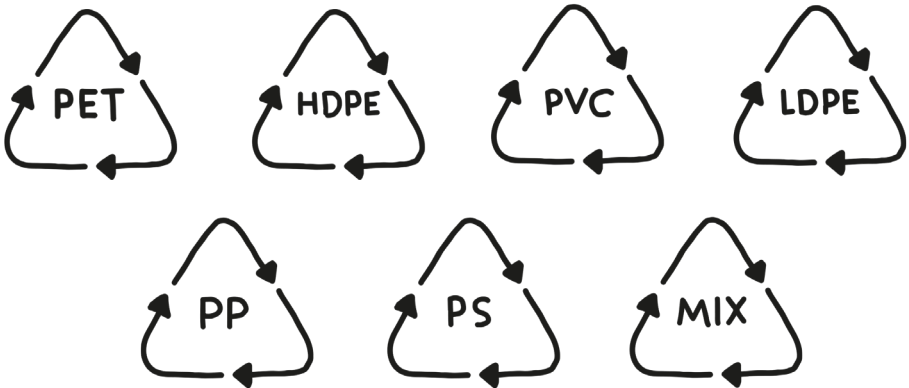
As you might have guessed already, we will focus exclusively on thermoplastics. From now on when we write “plastic” we will refer to thermoplastics.

2.4 Plastic types

Plastic (thermoplastics) are further grouped in seven different subcategories often referred to as plastic types. Each plastic type has its specific chemical composition, properties and applications and is given a specific number, called SPI code to differentiate between them. Today, most manufacturers should follow this coding system and place the SPI code on their products, usually moulded at the bottom of the product.

Knowing what plastic type you're working with is crucial when working with Precious Plastic. This will tell you its melting temperature so that you can set your Precious Plastic machines at the correct temperature and run a smooth recycling process.

The different plastic types are:



1. PET (polyethylene terephthalate)

This is a very strong plastic that can be easily recognised for its transparent look. All beverage bottles containing your favourite sodas are PET. This plastic is also used in many other products like jars, combs, bags, tote bags, carpets and ropes. Items made from this plastic are commonly recycled. Most recently, PET is often recycled into yarns to make clothes. This plastic is a bit more complex to work with, we advise to start with other plastics.

2. HDPE (high-density polyethylene)

This plastic is often used for food or drink containers. Items made from this plastic include containers for milk, motor oil, shampoos, soap bottles, detergents, and bleaches. Many toys are also made from this plastic. This plastic works very well with Precious Plastic.

3. PVC (polyvinyl chloride)

This is toxic and we do not work with it. PVC is most commonly found in plumbing pipes and releases chloride when heated up. Do not use with Precious Plastic.

4. LDPE (low-density polyethylene)

Plastic wrap, sandwich bags, squeezable bottles, and plastic grocery bags all are made from LDPE. Usually, LDPE is not recycled from the industry but works rather good with Precious Plastic.

5. PP (polypropylene)

This is one of the most commonly available plastic on the market. This type of plastic is strong and can usually withstand higher temperatures. Among many other application, it is consistently used for products that get in contact with food and drink (Tupperware, yoghurt boxes, syrup bottles etc..). PP works very well with Precious Plastic.

5. PS (polystyrene)

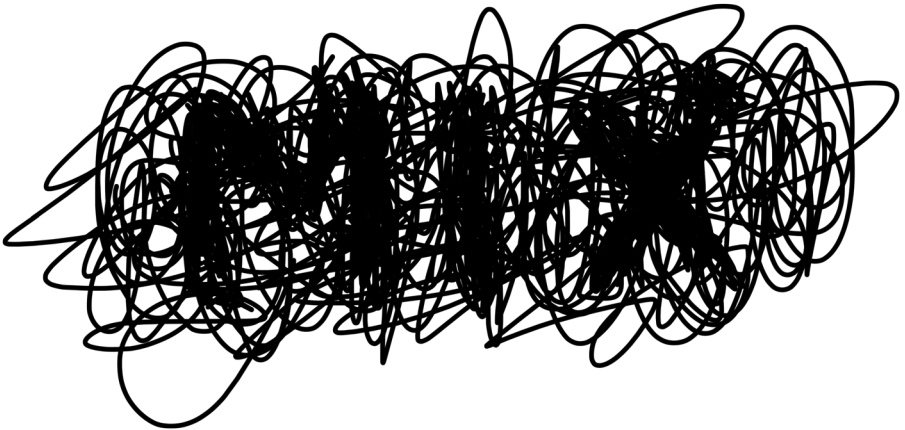
PS is most commonly known as Styrofoam. PS can be recycled, but not efficiently; recycling it takes a lot of energy, which means that few places accept it. Disposable coffee cups, plastic food boxes, plastic cutlery and packing foam are made from PS. Very good to work with Precious Plastic.

7. Other (Mix)

This code is used to identify other types of plastic that are not defined by the other six codes. ABS, Acrylic or Polycarbonate are included in this category and can be more difficult to recycle. Precious Plastic can work with some of this.

2.5 Mixing plastic

Different plastic types should never be mixed together when working with Precious Plastic as this will make it impossible to recycle them again. Mixing plastics would end their cycle. Moreover, when different types of plastics are melted together they tend to phase-separate, like oil and water, and set in layers resulting in structural weakness and lower quality products.



3.0

Plastic prep

Learn how to make your plastic ready for melting

TO DO:

- COLLECT
- SORT
- SHRED
- WASH

3.1 Collecting

The first thing a Precious Plastic recycling workspace needs is plastic to recycle. Pretty simple right? Without plastic to work with all processes will come to an halt. It is essential to always have enough plastic waiting to be sorted, shredded and worked with in order to run the workspace effectively. Plastic at this stage is still mixed and dirty.

Precious Plastic workspaces have one collection bag (with appropriate signage) outside of the space for people to drop plastic and one inside to be sorted in different types- this cycle enables a continuous process. When the collection bag outside is full the team should bring it inside and replace it with another empty collection bag. Once inside the bag has to be emptied from the plastic and sorted as soon as possible. When the bag outside is full again the process is repeated. This cycle should run at all time to ensure a smooth operation of the workspace.



The actual collection of plastic can happen in a number of ways depending on the cultural and economic context of your country as well as the partners you decide to work with. Some examples are:

- People from the Precious Plastic workspace collect plastic daily or weekly from their surrounding environment, friends and families. Very time consuming but powerful from a community perspective, and free.
- Find local shops or manufacturer that wants to get rid of their plastic because of production offcuts, leftovers or waste. This could mean greater quantities of plastic at once but it might come with a small financial compensation.
- Work with local waste pickers that are already collecting plastic in your town. You might have to pay pickers for their work but this could save you a lot of time and you could help them get a better living.
- Find a local waste stream that can offer you a constant supply of plastic (eg. industry, agriculture, fishing etc..)

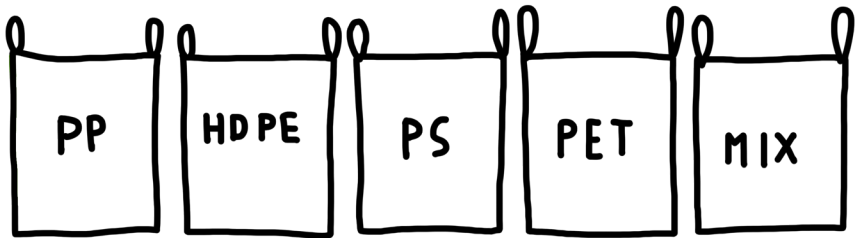


The collected plastic can be exchanged for money, awards or a big thank. This depends on your preferred choice, business plan, local environment and who your partners are.

3.2 Sorting

The sorting system is a crucial element for all recycling activities. A thorough and precise sorting effort guarantees smoother processes, better products and easier maintenance. An efficient sorting system allows the team to know exactly what plastic type is being used, which is crucial in order to figure out its melting temperature and set the Precious Plastic machines correctly to run the workspace efficiently.

Sorting is done manually (really?? Yes, even big industries still do it manually) by checking the SPI code (see 2.4 Plastic Types). Once the unsorted plastic comes in the workspace you should separate it in the relevant sorting bags (labelled with appropriate SPI code). Check each product for the small code (it can be numbers or letters in the triangular recycling sign), this is usually very small and can be difficult to find. Usually, it is embossed in the plastic itself at the bottom/inside of the product or printed on the label. Once you spot what plastic type the product is you can drop it in the appropriate sorting bag with the same SPI code.



Sometimes products don't have the SPI code because it either wasn't there in the first place or got eroded with time. In this case, you should put the product in the mix bag (number 7). If you have many of the same products without an SPI code you can try a number of alternative ways to discover what kind of plastic it is. The following techniques are less precise and not fully tested by Precious Plastic team and are intended to be a starting point for your own research on them.

Floating, this technique takes advantage of the different densities of plastic types. Each plastic type has its own specific density that will make it float differently in liquids. The floating liquid can be salted water, alcohol, vegetable oil and glycerin. This technique is used intensively by the industry. However, it can be very tricky, particularly because of the additives mixed with plastic that can change its density making it inaccurate.

Fire, this is a more extreme technique but it can work on certain occasions. Plastics have different properties when set on fire. For this technique, you should cut a piece of the unknown plastic and light it up observing the flame colour, nature and smell.

Smashing, plastic breaks in different ways when hit violently with a hammer. Some will smash in many pieces, others in bigger chunks while others will not break at all. Again, not perfect technique but it can help in certain situations.

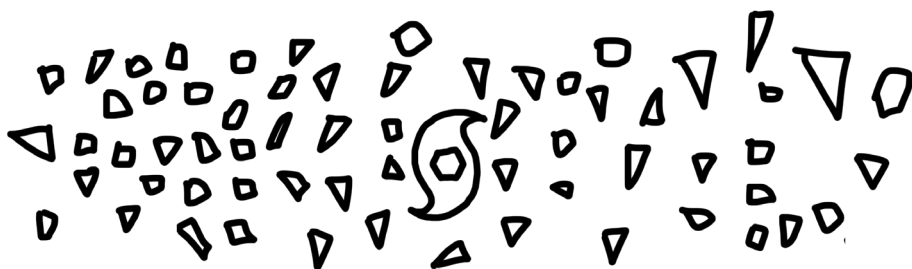
Sound, different plastic sound different if dropped on a paved floor. PP and PE, for example, sound very low while PS has a very high pitch and distinctive sound.

Scratch, thermoplastic and thermoset can easily be identified with this technique. When cut with a standing knife thermoplastic leaves a clean cut while thermoset creates little dust around the cut.

Type of object, often products are made from specific types of plastic. Water bottles PET, cd cases PS, jerrycans HDPE etc. This can be a way to distinguish which type of plastic it is.

3.3 Shredding

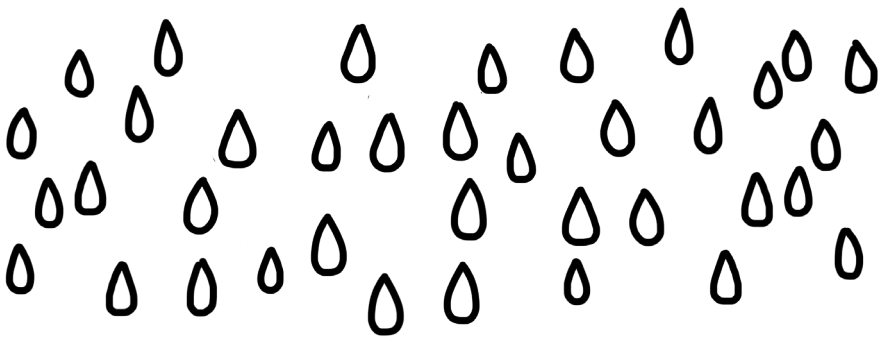
Once the plastic is sorted by their specific plastic type it's time to shred it. At this stage, bigger plastic objects are chopped into small granulate to reduce its size, enable washing, store more efficiently and be used with the other machines. It is good practice at this stage to separate plastic by colour. More info on the shredder and how it works coming up next in the Create Chapter (see 4.2 Shredder).



3.4 Washing

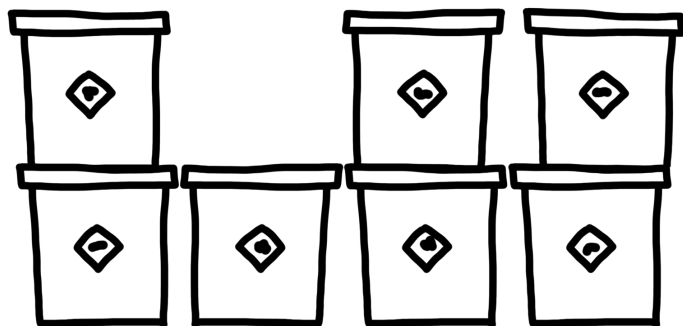
Plastic needs to be clean before undergoing recycling processes. We always recommend people to bring plastic clean. Dust, dirt and impurities will cause problems to Precious Plastic machines and processes. Dirty plastic can result in extra maintenance, breakdowns, problematic productions and low-quality products.

If plastic isn't clean collectors can wash it in barrels filled with water. A more efficient way is to wash after shredding using a basic filtering system. Plastic flakes are placed on a mesh and immersed in water. It is then thoroughly stirred 5-10 times and taken out. At this point, you should place the plastic on a drying plate for a few hours waiting for water to evaporate. It is important that the plastic is dry before being melted.



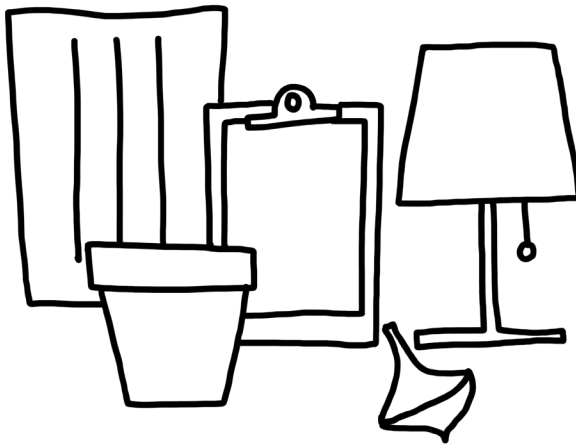
3.5 Storing

Once the plastic is dry it can be stored in the provided buckets. Ideally, buckets should be stackable, strong and transparent so you can see the colour and nature of the plastic. The SPI coding should be respected when storing the plastic using the provided Precious Plastic stickers. For example, if you have sorted, shredded and eventually washed PS it is essential that you put it in a bucket with the PS code sticker so that plastic does not get mixed up. The templates for making the labels can be found in our download-kit



4.0 CREATE

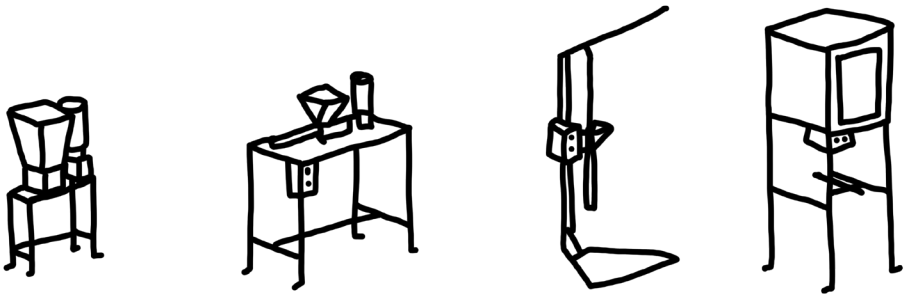
Learn about the machines
and how to make beautiful
products



4.1 Introduction

Overview

Precious Plastic have created four machines to recycle plastic. The machines are designed based on traditional industrial concepts but on a much smaller scale so that costs and knowledge's entry level can be kept to a minimum. This inclusive approach increases accessibility and adoption worldwide. The machines are developed using basic technologies and materials so they are easily understood, reproduced and repaired by people from all over the world with basic metal and building skills. The machines are also built in a modular way meaning that each part is independent and can be replaced, improved, changed, repaired and maintained individually without affecting the overall machine. We are always happy to see people hacking our machines and look forward seeing how you can make them better!

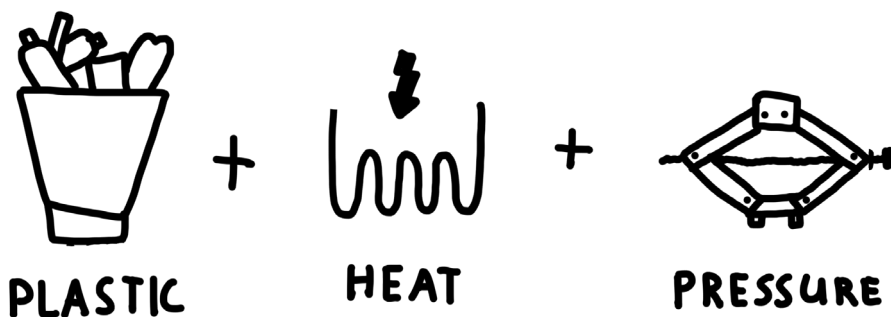


In this chapter, we will explain you how each machine works, how to create beautiful products, how to troubleshoot and repair the most common issues.

How it works

The underlying principle behind the machines is the same for all of them, except the shredder. The machines apply heat to plastic, plastic melts, gets pressed into a mould or shape and is finally cooled to regain its solid state. That's all the magic behind recycling. Pretty simple, right?

Each machine is unique with its own workflows, outcomes, precautions, behaviours and problems but the fundamental concept is the same. The more you'll work with them, the more you'll understand them and get better at recycling.



How to get started

Working with plastic is not easy, it takes time and dedication- just like any other craft. It is important you first learn about plastic, the way it behaves and works under different conditions. In the early days of your journey into plastic you should get a feeling of how it melts, how it cools, when it burns and why or how to polish and finish it to make great products.

Beside getting experience with plastic it is also important to develop some degree of expertise on different materials and how they work with plastic. This is particularly important when you will try to make new

moulds on your own. Knowing what material conducts heat most efficiently, which one releases plastic easily and other key material insights will be crucial to your success.

Before getting started there are a few general things that apply to all machines to take into account:

1. Read the manual

If you are new to Precious Plastic and recycling always give a full read to this manual. It contains key information about plastic and the machines. This will save you time, help you get the best products, not break the machines as well as keep yourself safe and healthy.

2. Safety

A number of international research papers have been written on the safety of working with plastic. Opinions are often in contrast on whether heating plastic is dangerous or not. Many researches show that keeping the temperature of the plastic within the melting zone (not burning it) isn't harmful. This also depends greatly on which plastic type you are working with (this is why sorting is so important). While researching we personally noticed most people working in the plastic industry operate according to this rule. However, not fully trusting the plastic industry we like to keep it on the safe side- always try to avoid inhaling any plastic fumes, wear carbon-mask when working on the machines and make sure there is good ventilation at all times.

The machines work at few hundreds degrees and require people operating them to be always very focused and concentrated to avoid burning or

set stuff on fire. Particular attention should also be kept at all times when working with the shredder as its blades are sharp and tend to grab things. Never work with long sleeves or loose gloves with the shredder.

3. Choose your plastic and start easy

There are many plastic types to choose from. Each having their own properties and behaviours (flexible, hard, liquid etc.). A few are easier to work with because, amongst other things, they have a longer melting zone. We suggest to start with PP, HDPE, PS since they are much easier to work with and will make your life a lot easier.

3. Temperature

With every recycling process, the first step is to figure out which temperature is needed to melt the plastic. Most of the time this depends on the plastic type you are working with and the room temperature at which you're operating (eg. if it is windy the heat will disperse faster). Unfortunately, plastic is often mixed with additives, pigments and fillers that transform its chemical and physical composition affecting the final melting temperature. Don't be surprised if sometimes the recommended melting temperature does not achieve the desired molten state, try to gradually adjust your temperature up or down until you achieve the desired melting.



4. Do not burn plastic

This might seem obvious for some but worth repeating. Plastic should never be burned, at home or while working with Precious Plastic. Fumes from burning plastic are highly toxic and can cause serious health issues to humans. For the recycling process it is also extremely bad practice to burn plastic as the resulting products will be damaged or lower quality. All plastics have a melting zone, which is a temperature window between which they melt (eg. 130 to 171 °C), beyond those temperatures plastic will begin to burn. Try to avoid that at all times.

5. Moulds

Moulds are an integral part of the Precious Plastic ecosystem and could almost be considered a world on its own. Moulds give shape to the molten plastic and create the final product. Entire teams of designers and engineers dedicate their lives to develop moulds to make most of the stuff around us. At Precious Plastic we do not specialise in mould development and open sourcing, yet. Your team should look into ways of creating new

moulds to make new products and push plastic recycling to its limits. We share techniques-videos on our website to show you different ways how to do this.

Moulds can be made using different materials but we generally advise to work with metal for its durability and better capacity to conduct heat (more energy efficient). Metal can be shaped in a number of ways, which one you will use depends on what kind of object you intend to make and what technologies you can access. For instance, you could use a more hands-on approach and create new moulds using a welding machine (a bit more rough), a milling machine or a lathe. Or you could create a digital file and use more advanced (and expensive) technologies like CNC (very precise).

We advise to spend some quality time thinking, designing and making an accurate mould so you can create better products. This will pay off in the long run.

6. Make plastic valuable

We believe plastic should not be seen as disposable and cheap. We strive to make plastic valuable, create objects that last long and that people cherish. Put care in that, love what you create and start seeing plastic in a whole new way to inspire others around the world. Creating beautiful, more expensive and valuable objects will avoid you having to compete with dancing cheap oil prices - people will buy your products because they want it, not because they are cheap. This is better in the long run so you can put more effort in the things you make as you will get greater

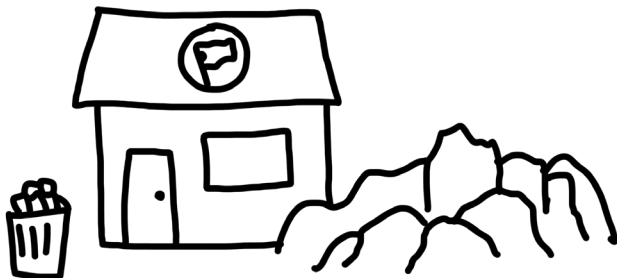
profit- and most importantly plastic products won't end up in the environment again.

7. Share your creations back

Our community is the backbone of the project. Go to our forums (davehakken.nl/community/forums) or website to see things made by others and make sure to share back the things you make. Help to fuel the project forward! Together we can find a solution to the plastic problem that works, is fun and improves everyone's life.

Take it to the next level

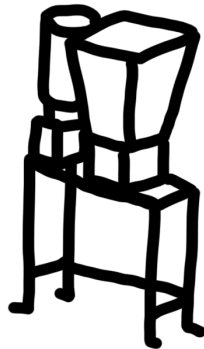
Precious Plastic provides you and your team with the basic framework to run a recycling workspace effectively. It is up to you and your team to bring it to the next level. Create new products, new moulds, hack the machines, maybe make new ones, invent, collaborate with other craftsmen, experiment, share your knowledge, teach other people, invent new reward systems to collect plastic or bring new people to the workspace you never know where winning solutions will come from. Be open and collaborative.



4.2 Shredder

Intro

The shredder machine is a key element for a fully functional Precious Plastic workspace. The shredder enables you to chop bigger plastic objects into smaller flakes that are easier to store, wash and introduce in the other machines. The shredder helps your process to be more efficient and fast. Shredded plastic is easier to work with and melts easier. The plastic industry buys shredded plastic at a price 8 to 10 times higher than not-shredded plastic, making the shredder machine particularly important when selling back to the industry. The shredder is the backbone of any plastic recycling workspace.



Process

When you're ready to shred some plastic the first thing to do is to choose the plastic type, this usually depends on the quantities of plastic piling up in your sorting bags. Make sure you have enough plastic (of the same

type) as the shredder needs a little set up (cleaning) between cycles of different plastics. Once you have chosen the plastic type it's time to break up bigger plastic objects into smaller chunks that can fit in the hopper. This can be done with a hammer, scissors or a saw depending on the plastic. At this point you should also roughly clean the plastic from major dirt, don't waste too much time on this though (plastic will be washed shortly after).

Now you're ready to insert the smaller plastic chunks in the hopper and wait for the blades to chop them until small enough to get through the mesh (the mesh defines the size of the output plastic). At this stage, you should regularly check the blades and push the plastic down towards the blades with the provided tool to make sure the blades are grabbing the plastic. Always use extra care when working with the shredder.

When you finish working with the shredder make sure to store away the shredded plastic or the next person using the shredder won't know what plastic type is in the bucket.

How to operate the shredder

1. Gather the sorted plastic you want to shred.
2. Separate in colours.
3. Check if the mesh is installed with the right hole size.
4. Turn on the machine.
5. Put in the plastic and wait.
6. Store the shredded plastic.
7. Clean the machine.

Changing plastic type

1. Stop the machine, take out the plug.
2. Remove the mesh underneath with 4 screws.
3. Remove the little shredded flakes in the machine with a brush, optionally blow it out with pressured air.
4. Put the mesh back in and shred another type of plastic.

Trouble shooting

1. Sometimes the blades don't grab the plastic. Try pushing the plastic towards the blades with the tool provided. Never attempt to do that with your hands.
2. If plastic resistance exceeds the maximum torque of the motor, the machine will stop. Basically, there is too much plastic to be cut and the motor can't make it. Switch off the machine and remove some of the clogged plastic.

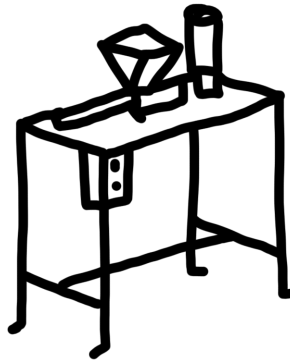
Tips & tricks

1. We often shred by colour, this way plastic can become our paint. First choose the plastic type, then pick a colour you have plenty of and shred it. Don't mix different types of plastic to match a specific colour.
2. Clean the shredder blades and mesh every time you change plastic to avoid contamination of different plastic types.
3. Wear protection goggles as some plastic could jump off the hopper.

4.3 Extrusion Machine

Intro

The extrusion machine is a very powerful machine of the Precious Plastic arsenal as it can create unique products and can run continuously. Technically, if you have enough plastic and a well-streamlined process you could be recycling 24/7. With the extrusion machine you can create filament, granulate or get creative working with moulds. This machine is also great for educational purposes as the process is very straightforward and easy to understand. This technique nicely blends differently coloured plastics together and outputs a homogeneous and smooth colour, for example, if you mix black and white plastic together you will get a nice and smooth grey output. You can use this feature to your advantage in your designs.



Process

Plastic is inserted from the hopper, gets transported along the barrel by a big screw towards the end where heating bands are placed. The heating

from the bands and the mounting pressure inside of the barrel bring the plastic to a melting state (liquid). Once sufficiently melted the plastic can eventually get out through the nozzle in the form of a continuous thread. The plastic thread is then treated differently depending on the wanted outcome.

Create

Once the extruded thread exits the nozzle it can be treated in a number of ways in order to get the desired results. For the sake of this publication, we will only describe the process using the provided mould, other ways to create filament for 3D printing or pellets can be found online. When the plastic comes out of the nozzle it is still semi-liquid (and very hot!), this gives us a few seconds to shape it around our mould. The fresh hot thread coming out of the nozzle is placed around the mould over and over until a new object is created. Hot new plastic and previously layered threads will melt together to create a new solid material. Repeat this process multiple times around the mould and you'll get a new product. While very straight-forward at first, this process requires a bit of experience and good hands-on approach but anyone should be able to make some cool objects after a few attempts.

Moulds

With the lamp mould from our technique videos you can make a lamp, it is simple and straight forward for anyone to understand how it functions. It is made with steel and can be reproduced by any metal worker around the world. An important aspect to keep in mind is to design the mould

with convex walls (not completely straight) to help release the final product. Technical drawings for this mould are available online.

Temperature

You can set the temperature from the controllers on the electronic box. The heating elements are wired into two groups (Nozzle and Barrel marked on top of the controllers) first three elements (Barrel) should be set at slightly lower temperature than the last one near the nozzle. This is to make sure the plastic gets a last boost of heat right before it comes out. Below you can find a diagram with the best settings for this machine based on our experiments (tip: you could make one of your own to see what works best for you). The optimal temperatures below are drawn using a motor turning at 70rpm. If your motor turns faster you would need higher temperature as the plastic flows faster through the barrel and has less time to melt, vice-versa if the motor is slower.

How to operate the extrusion

Startup

1. Heat the machine to the desired temperature.
2. Wait 20 minutes.
3. Add desired plastic in the hopper.
4. Turn on the motor.
5. The material that comes out of the machine for the first 2 minutes is to clean the machine from old plastics from previous sessions.
6. The machine is now ready for production.

Production

1. A plastic string is now flowing out of the extruder, this can not be easily stopped, so know what you want to make before you start extruding.
2. The flow and pressure of the extrusion can be adjusted by turning the screw at the nozzle (more flow equals less pressure).
3. Remember that it takes roughly 2 minutes for the plastic to reach the nozzle from the hopper.
4. Keep enough plastic granulates in the hopper while extruding to reduce chances of bubbles in the extruded plastic.

Cooldown

1. When cooling down the machine let the machine turn until there is no more material coming from the nozzle.
2. First stop the motor than the heating.

Type	Barrel	Nozzle	Time
PP	190°	210°	-
PE	190°	210°	-
PS	210°	230°	-

Trouble shooting

The most common problem with the extrusion is having an output that is not uniform. There are a few reasons why this could happen.

1. The plastic can be dirty clogging the nozzle and making it difficult for the plastic to get out.
2. Two different types of plastic are mixed together, common causes for this can be contamination in the sorting stage or plastic left in the barrel from previous activity. In this case, one plastic type melts while the other doesn't obstruct the plastic flowing through the nozzle.
3. The temperature is not high enough and the plastic in the barrel does not manage to fully melt.
4. You can solve the above problems by checking the integrity and purity of the raw material or by highering the temperature. Upon adjusting your process make sure to empty the entire barrel before attempting to make a new product.

Tips & tricks

1. Change the nozzle output size to experiment with different thread sizes and see what settings you prefer, we've seen great examples at both ends of the spectrum (bigger or smaller).
2. Run the machine with two people if you can, directing the extruded thread and refilling the hopper can be hard to be done simultaneously by one person alone.
3. If you change plastic let the machine run for a few minutes to make sure the barrel is clean from the previous plastic type or you'll en-

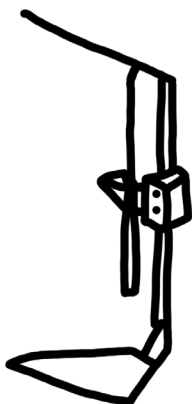
counter some problems.

4. Make sure there is always plenty of plastic in the hopper.

4.4 Injection Machine

Intro

The injection machine is a rather fast machine that allows for small productions of very precise objects. Moulds can be slightly harder to make but once you have a good mould you will be amazed by the products you can make with it. The injection machine can usually make smaller objects depending on the barrel's volume but operates at faster speed and with high precision. The output colour is often unpredictable when mixing colors in the barrel allowing for surprising patterns that can add to the beauty of your products.



Process

The plastic enters through the hopper filling the barrel until needed depending on the size of the object you want to make. The heating elements bring the barrel to temperature and melt the plastic inside. After 15-20 minutes, depending on the plastic type you're working with and the volume, the plastic is molten and ready to be injected into the mould using the hand-powered metal lever. Right after the injection the mould can be cooled, this can be done either with air or cold water (faster but can cause rust). Wait until the metal is cold and you're ready to open your mould and see the results.

Create

Creating products with the injection machine can be a little more difficult as it requires a good mould upfront. Depending on the type of plastic the lever can be pressed by one person or two if more pressure is needed to inject the plastic.

The process in itself is tightly connected with moulds and mould making. If you have a precise mould you can create beautiful products in a matter of minutes and start a little local production. Before injecting the plastic in the mould you have to make sure that the plastic in the barrel is fully melted in order to fill all areas of the mould. To achieve this run the machine a few degrees higher than usual to certify the plastic is fully liquid.

Moulds

With the tile mould from our technique videos you can make octagonal tiles, it is simple and straight forward for anyone to understand how

it functions and can work beautifully in series. You can make facades, pavements or tables- we can't wait to see what you can do with them! The mould is made welding different steel parts together and can be easily reproduced by any metal worker around the world. We highly encourage you and the team to look into making new moulds to create products that fit your market. Technical drawings for the starter mould are available online.

Temperature

Below you can find a diagram with the best settings for this machine based on our experiments (tip: you could make one of your own to see what works best for you). You can set the temperature from the controllers on the electronic box. The heating elements are wired into two groups (Nozzle and Barrel marked on top of the controllers) with different temperatures, first three elements (Barrel) should be set at slightly lower temperature than the last one near the nozzle (Nozzle). This is to make sure the plastic gets a last boost of heat to get more liquid right before being injected into the mould.

Material	Barrel	Nozzle	Time
PP	190°	210°	15 min
HDPE	190°	210°	15 min
PS	210°	230°	15 min

How to operate the injection

Startup

1. Turn the machine on and set the temperature to 20° more than the desired temperature. Make sure the lever is completely at its lowest position.
2. Wait for at least 20 minutes.
3. Turn the temperature down and fill the barrel with the desired plastic.
4. Wait another 15 minutes for the plastic to melt, the first batch of plastic is more to rinse the machine and to get rid of plastics from previous sessions.
5. Press the first batch of plastic out of the machine.
6. The machine is now ready for production.

Production

1. The machine is now warm and ready to produce.
2. Fill the barrel with the desired plastic.
3. Press the lever in the barrel.
4. Pull the lever up every 5 to 10 minutes and add more plastic.
5. Wait 10 minutes or more.
6. Unscrew the brass screw at the bottom.
7. Screw in the mould (be quick or plastic will start to flow out!).
8. Once the mould is secured to the machine pull the lever down as far as possible, don't be scared to give it a lot of pressure, it can easily hold a 100kg.
9. Unscrew the mold from the machine.

10. Pull the lever up.
11. Screw the brass screw in place.
12. Fill the machine for a new product.
13. Let the mould cool.
14. Open the mould once it is cooled down.

Cooldown

1. When you turn off the machine empty the barrel completely, this makes it easier for the one using it after you.
2. Leave the machine with the lever all the way down.
3. Turn the machine off.

Trouble shooting

1. If the plastic is clogging at the end of the barrel and doesn't come out even when applying higher pressure, then rise the temperature of the nozzle heater to fully melt the plastic and release the block.
2. The final product might get stuck to the mould making it hard to release, if this happens gently re-heat the mould to soften the plastic and help release.

Tips & tricks

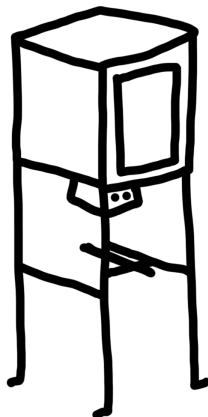
1. The hotter the plastic the greater the sink marks on the final product.
2. Clean the mould from plastic when still warm or it will be harder later.
3. Use mould release on the mould, helps with release.
4. We like to keep the barrel full with plastic at all time adding a bit of plastic with each injection.

5. When you finish working with the injection machine make sure you empty the barrel from plastic.
6. To create an efficient process it is advisable to run the machine for a few hours once it is started. Don't start and stop the machine too often as the process will be very inefficient.

4.5 Compression Machine

Intro

The compression machine consists of an electric kitchen oven to heat the plastic and a carjack to apply pressure to the mould. The process is generally slower but it allows bigger objects to be crafted. This machine can also be used to create new raw material like big sheets of plastic that can be further treated with other techniques to make new products. When mixing different coloured plastic, the compression machine gives a specific flake-like look to plastic that can be used to your advantage.



Process

The mould, loaded with plastic, is placed in the middle of the oven tray. Set the correct temperature and wait for some time (30-40min) depending on the plastic type and start turning the carjack. The turning pushes the tray against the ceiling of the oven creating pressure in the mould and spreading the plastic homogeneously in all areas. Wait a minute or two and release by unloading the carjack. Withdraw the mould from the oven and cool in water or air. Once the mould is cold you can open and check your new product.

Create

The compression is simple to understand and very powerful if properly mastered. It can be operated by one person alone most of the time. Once again, the creation process is very connected with moulds and mould making. If you have a precise mould you can create beautiful products. The mould we provide is very basic so everyone can understand the process but we highly encourage you and the team to look into making new moulds that can be useful in Kenya.

Moulds

With the bowl mould from our technique videos you can make an octagonal bowl, a functional and beautiful product to store, transport and display food or objects. The mould is basic and straight forward for anyone to understand how it functions, it is made with steel and can be reproduced by any metal worker around the world. Its convex nature is key for an easy release of the final product. Technical drawings of this mould are

available online. Once you master this mould why not trying to make a new one to create new products?

Temperature

Below you can find a diagram with the best settings for this machine based on our experiments. In the compression machine the room temperature does not affect the process. You can set the temperature from the controllers on the electronic box. With this machine there is only one temperature you have to set, bear in mind that the temperature between the top and the bottom of the oven might be slightly different.

Material	Temp	Time	Weight
PP	200°	40 min	425g
HDPE	200°	40 min	425g
PS	220°	40 min	425g

How to operate the compression

Startup

1. Turn the oven on and set the desired temperature.
2. Wait 20 minutes for the desired temperature to be reached.

Production

1. Weigh the required amount of material for your mould + 20%.
2. Fill the mould with material.
3. Put the upper part of the mould on the plastic.
4. Put the mould in the oven.
5. Leave it for 15 minutes.
6. Turn the mould 180° in the oven.
7. Leave it for another 15 minutes.
8. Compress the mould.
9. Take the mould out of the oven.
10. Put clamps on the mould to keep the pressure.
11. Place another mould in the oven.

Cooldown

1. Clean the inside of the oven from molten plastic.

Trouble shooting

1. Plastic overflows from one side of the mould. This is often the result of misalignment between the mould, pressing plate or the oven itself. Make sure everything is as much as possible parallel to the ground.
2. Product gets stuck to the mould. Try softly heating the mould to ease the release or try to apply a layer of mould-release to the mould.

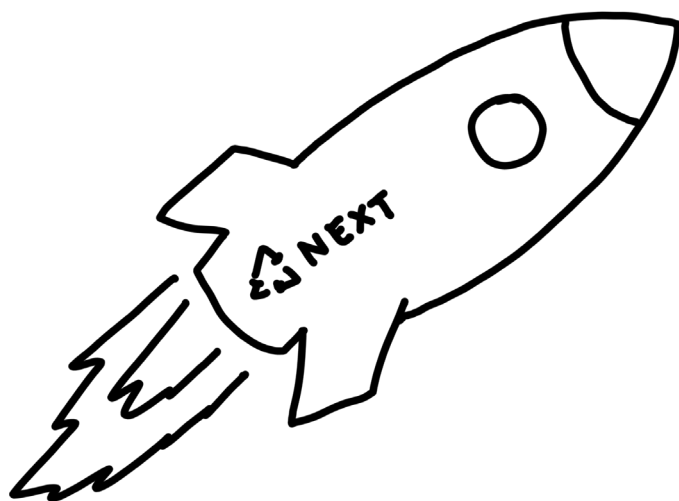
Tips & tricks

1. It is advisable to heat up the plastic first until melted and then apply pressure.
2. Don't be hasty, make sure the plastic is fully melted in the mould.

4.6 Final thoughts

The above processes are a starting point, not an end goal. They should inspire you and get you started, spend some time mastering them. Once you're confident you understand how they work and how to work with plastic why not trying to go off road and test new ideas, moulds, processes and techniques?

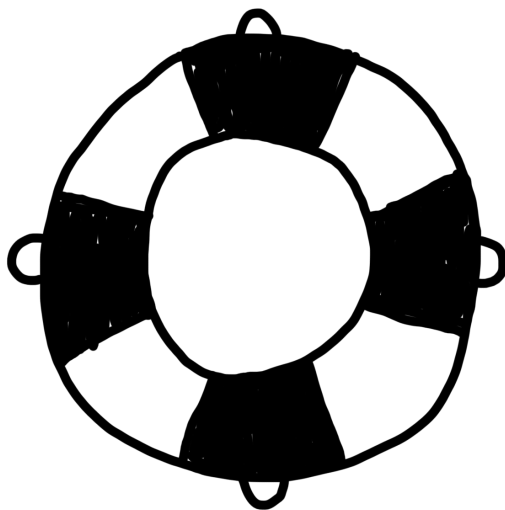
We look forward to see where you and your team can take this project, pushing the limits of plastic from Kenya.





5.0 EXTRA

Help, share, forum & more



5.1 Need help?

Are you having some trouble working with the machines or making products? Are you stuck or need assistance? There are a few useful ways and places to find help from the Precious Plastic team or community.

Website

Our website is a good place to start. There you can find a lot of information, video tutorials, documentation and tips on how to run a Precious Plastic workspace. Go to www.preciousplastic.com and start browsing to gather more knowledge on the topic. Studying the website and videos in deep will give you the basic knowledge to find help and talk about plastic on the forum with other people around the world.

Forum

The forum is the place to go to find answers to more complex questions. The forum is where our community and fellow recyclers meet and try to find answers to their questions. Over the years the place has evolved into a useful (and extensive!) resource for people working on Precious Plastic with lots of helpful knowledge and hundreds of specific topics on our machines and methods. Most of your questions (especially in the beginning) have probably already been tackled on the forum, make sure you dig deep in the forums to find your answers. If you still can't find what you're looking for you can post a new topic and wait for a reply.

Map

The map can be a great source of inspiration. There you can find more people working on Precious Plastic around the world (maybe near you!). The map showcases people that built machines, set up shops, sell & fix machines and make products. You can contact people directly if you have questions or want to get in contact. <http://map.preciousplastic.com>

Youtube

Yes, you've heard it right. Youtube is a great learning platform where a lot of knowledgeable people explain stuff in great details. At Precious Plastic we often refer to Youtube to troubleshoot and find solutions to our plastic problems. Give it a try, it's fun!

Local guy

Often if you're looking for more technical and hands-on expertise when it comes to moulds or metal in general a local metal worker in town would be a great place to start. They are usually very experienced and knowledgeable on the topic and can offer greater explanation than any other digital sources.

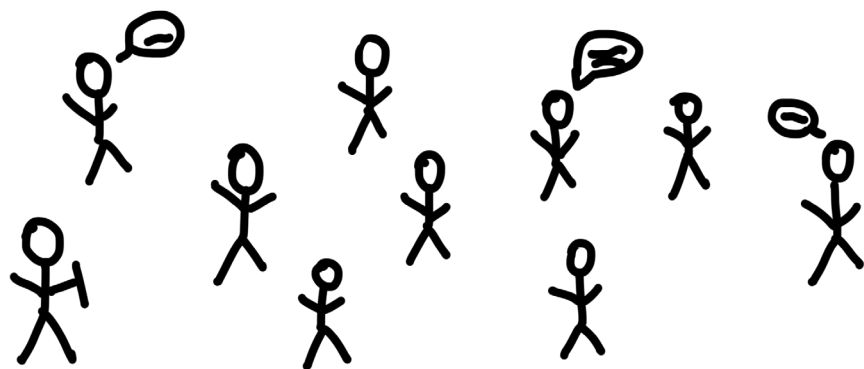
Updates

Precious Plastic is in constant evolution, we keep improving our machines and techniques to fight plastic pollution. Precious Plastic evolves in versions, meaning that every year or two we release a new version with new features for the machines, products, tutorials, websites, collaborative tools and the forum to make Precious Plastic more efficient, relevant

and increase our impact. If you regularly check www.preciousplastic.com you can make sure to be up to date with the latest developments of the project.

5.2 Activate your community

The more people are involved in the project the more plastic will be recycled and reused, helping to solve the environmental and health issues connected to plastic pollution across the planet. Precious Plastic is about inclusive collaboration and builds upon sharing knowledge and tools between friends, family, neighbours, cities, countries and nations. Don't hold your knowledge, offer what you've learnt and know about plastic with the international community of recyclers so that we can work together to fix this problem.



Create workshops, open days, visits, training, school days and events around the Precious Plastic workspace to involve an ever greater portion

of society around you to educate and learn about plastic, how to work with it and how to create amazing new products from discarded plastic. Share your learnings, experiments or failed tests back with the community so more people can learn from you or help you to improve and overcome your difficulties.

You are now part of the Precious Plastic global family!

5.3 Feedback

We understand this is the boring part. However, this is also one of the most important part of the project. If we learn from your opinions, experiences and problems we can improve Precious Plastic for you and for the next people working on this. The problem you will encounter, misunderstandings, inconsistencies, unclear descriptions or stuff that just feels like it could be improved is all super valuable feedback material for us to fix issues and grow better, together. In a hot sunny day or while waiting for a bus we would love if you could take the time to write us an email or post a topic on the forum with feedback on the project.

HAVE FUN!



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