

Mini-guide

Solutions to make boards with recycled plastics



Key learning outcomes:

- *A better understanding of the challenges facing board making with recycled plastics*
- *Benchmark of technical solutions*
- *Benchmark of outcomes*



Credits - Precious Plastic

Table of content

Introduction	3
Presentation	3
Characteristics of a well-made board	3
1. The different board types	4
Oven + press	4
Kiln + press: the example of Capobianco Soluciones, a semi-continuous recycling line for large slabs, Colombia	5
Furnace + press: the example of Cedar Environnement, wood-fired furnace, Lebanon	6
Kiln + press: the example of Robries, gas kiln and plate pattern creation, Indonesia	7
Heated press + Press	8
Heated press + Press: the sheetpress V4 from Precious Plastic	8
Heated press + Press: the example of Plastic Lab, Lebanon	10
Heated Press + Press: the example of TRS (The Recycle Studio), the best-quality plates from the Precious Plastic ecosystem, Costa Rica	11
Heated press + Press: the example of Sungai Watch, plastic bag recycling, Indonesia	12
Making polyaluminum sheets: the example of Ecotex and Proplast in South America	14
Making plates with an extruder	15
Making plates with an extruder: the example of Ecolab8, Indonesia	15
Making sheets with an extruder: the example of IPS Madera Plastica, Costa Rica	16
2. Treatment of cooled plates	18
Works on surface finish and edges	18
Shaping and assembly techniques	18
3. Production tips for making recycled plastic sheets	20
Plate mold architecture	20
Tips for achieving high-quality plates with a hot press	21
Practical extras to make life easier	22
4. Possible outlets for these ecological boards	24
Semi-finished product: Who can I sell recycled plastic sheets to?	24
Finished product: What to do with recycled plates	25
Examples of companies and finished products around the world	25
Conclusion	32



The contents of this guide are proposed in **open source**

NB: The information in this guide is part of a long-term project, and is likely to evolve and be refined as our research progresses. All feedback is welcome by email to jean-baptiste@plasticodyssey.org. Thank you!

Introduction

Presentation

Like extrusion lines, recycling lines to make boards represent a semi-industrial solution for processing shredded plastic waste. The special feature of plastic plate recycling is that, unlike extrusion, the plastic flakes are not mixed. This results in a non-uniform surface color.

Characteristics of a well-made board

- Good surface finish (absence of flakes, bubbles, corrugations, blisters)
- Good, even thickness throughout the sheet
- Good texture with no holes inside the plate
- Well-marked corners and edges



1. The different board types

There are two main approaches to the manufacture of boards from shredded plastic waste:

- The lines : **oven + press**
 - Here, a furnace is used to heat the crushed material distributed in the plate mold. Once the crushed material has melted, the mold is placed in a press to precisely shape the molten crushed material, compressing it until the plastic plate cools.
- The lines : **heated press + "cold" press**
 - In this approach, the shredded material is compressed at the same time as it is heated (thermocompression). Once all the shredded material has been melted and compressed, the plate is placed in a cold press to retain its shape while it cools.
- The lines : **extrusion + "cold" press**
 - In this approach, the milled material is melted and mixed in an extruder, then deposited in a lower mold which, once filled, is moved into a press to shape and cool the material. Alternatively, the material can be directly shaped by intrusion into a wide, plate-shaped closed mold at the extruder outlet.

Oven + press

This approach is the less complex of the two. The two main machines each focus on a single function and are standard machines, i.e. heating on the one hand, and pressing to shape on the other. For the same production capacity, this would appear to be the least expensive type of die in terms of machine investment.

This is the type of assembly [oven](#) + [press](#) on board. The oven is an item that can be found anywhere in the world second-hand. A kitchen oven will do the trick just fine. Be careful, however, not to limit yourself too much in the size of the baking trays, depending on the intended use.



For the shaping stage, we have a hydraulic press on board to compress the molds. Note that this equipment is used for other purposes, and is largely oversized for platemaking. It is therefore possible to use hydraulic or mechanical hand presses to shape the plates. You'll find more illustrations of this type of press in the next section, dedicated to the example of Precious Plastic machines.

Please note that many projects do not achieve even heating of their shredded material when it is in the kiln. Consideration needs to be given to the types of heating (convection, conduction, radiation), the influence on heating of a pressurized grind (where heat should circulate better from one grind to another) and the positioning of the heating elements.

The simplest way to remedy this would be to have heating elements above and below the plate. Heating times can then be adjusted to balance the heating (see Robries example). It may also be possible to work with a rotating-heat oven. It also remains to be seen how thick the crushed material can be to maintain even heating without pressure...

Kiln + press: the example of Capobianco Soluciones, a semi-continuous recycling line for large slabs, Colombia

Because sheet metal is manufactured piece by piece, the throughput of most sheet metal production lines is often conditioned by the size of the sheets, hence the interest in working with large parts.

Machine manufacturers such as Mexico's HEATmx have developed systems for producing large sheets of variable thickness (1.3m x 2.4m, 1.2 cm thick) in a

semi-continuous process, by placing the molds on racks so that they can be transported from the oven to the press.



The process can be broken down as follows for information 12 plates of 40kg :

- Liquid silicone film applied with a cloth to the bottom of the mould as a release agent
- Add crushed material
- Homogenize crushed material in mold
- Heating: 10 min 180 degrees + 40 min 225 degrees
- Pressing: press for 40 minutes at 1200-1500 PSI with 8-degree coolant system
- Demolding
- 24h shaping



This system and its operation are described in greater detail in the case study [Capobianco Soluciones](#).

Furnace + press: the example of Cedar Environnement, wood-fired furnace, Lebanon

Ziab Abichaker, who we met during our stopover in Lebanon, uses his plate production line to recycle waste that cannot be recycled through more conventional channels:

"We approach things in a very pragmatic way. As an engineer, I'm looking to build sorting, composting and recycling plants. I've developed the ECOBOARD technology, which enables us to recycle even plastics that are not considered recyclable. In the sorting center, PET and HDPE are collected, compacted and sold to recycling companies. The remainder is used to manufacture ECOBOARD panels. This technology proves that you don't need a landfill, you don't need an incinerator. We don't have to bury or burn anything!



Kiln + press: the example of Robries, gas kiln and plate pattern creation, Indonesia

[Robries](#) is a well-established Indonesian project with a good order book (over €400k in sales by 2022). Being based in a territory with unreliable access to electricity, Niam and his teams have equipment that operates without electricity. Their reproduction relies on several gas ovens and hand-operated hydraulic presses. The production process is detailed in the following Precious Plastic video:

[Video Precious Plastic : How to recycle PLASTIC with a bread oven | ROBRIES](#)



Example of manufacturing parameters:

**LDPE, sheet size 90cm x 40 cm, thickness 1cm, 4 kg
heating to around 150°C, they start 15 minutes only with the lower heater, then add the
upper ones for a total oven time of 45 minutes
cooling in a press for 60 minutes**

To draw patterns in the plastic, the plate is removed from the oven after the first 15 minutes of baking, and patterns are drawn by passing a screwdriver over the surface. The plate then returns to the oven for the remainder of the heating time.

Whether at Capobianco Soluciones or Robries, the fact of using an oven often leads them to have different surface qualities between the top and bottom of the plate.

Heated press + Press

The other idea is to heat the press platens... With integrated heating elements, heat is transmitted directly to the plastic by conduction, while the shredded material is kept under pressure...

Heated press + Press: the sheetpress V4 from Precious Plastic

In 2020, [Precious Plastic](#) shares the plans for the 4th version of its open-source recycling machines. With these new machines, Precious Plastic's ambition is to offer semi-industrial-scale equipment, whereas until now the aim of previous versions was more to give everyone access to machines enabling small-scale, symbolic recycling. The aim here is for this new range of machines to enable the structuring of real recycling activities with paid employees and greater quantities of waste absorbed.

The biggest success of the V4 range is undoubtedly the sheet press. It can produce sheets measuring one meter by one meter, with thicknesses ranging from 6mm to 30mm, or around fifteen kilos.



This model of machine is spreading rapidly around the world in many recycling workshops. Find out more about these machines on the Precious Plastic website:

[Precious Plastic heating press presentation page](#)

[Precious Plastic complete kit download page \(machine drawings, business case...\)](#)

The heated press is also accompanied by a preparation table and a cold press for forming. As always at Precious Plastic, plans are freely available, but you can also find a Precious Plastic machine builder around the world on the [Bazar](#). The set of preparation table + heating press + press is proposed for purchase at around 8-12k€.



[Video : Precious Plastic - Setup a plastic sheetpress workspace](#)




As a starting point, the Precious Plastic teams provide us with the following information as heating parameters:

Sheet thickness	HDPE 220°	PP 230°	PS 240°
6MM	6.5 KG 40 Min	6.5 KG 40 Min	6.5 KG 40 Min
8MM	8.5 KG 45 Min	8.5 KG 45 Min	8.5 KG 45 Min
10MM	11 KG 50 Min	11 KG 50 Min	11 KG 50 Min
12MM	12 KG 55 Min	12 KG 55 Min	12 KG 55 Min
20MM	22 KG 60 Min	22 KG 60 Min	22 KG 60 Min

Heated press + Press: the example of Plastic Lab, Lebanon

In Lebanon, Ralph Boujri, co-founder of Plastic Lab, has started recycling household waste to make furniture (tables, benches, chairs, deckchairs) and bricks. He is equipped with precious plastic machines, including a heated press.

It transforms different types of material into slabs. Below you can see the different process parameters according to the materials and plate thicknesses he produces.

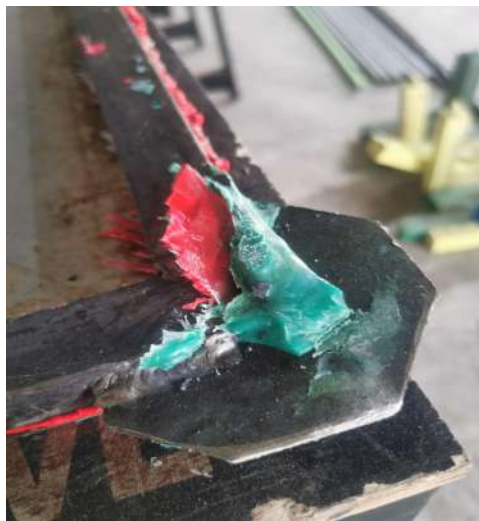
Sheet Thickness	HDPE  220°C	PP  230°C	PS  240°C	Cooling Time
4mm	4.5kg 1st press: 25min 2nd press: 10min	4.5kg 1st press: 25min 2nd press: 10min	4.5kg 1st press: 25min 2nd press: 10min	1:30 hrs
6mm	6.5kg 1st press: 30min 2nd press: 10min	6.5kg 1st press: 30min 2nd press: 10min	6.5kg 1st press: 30min 2nd press: 10min	1:30hrs
8mm	8.5kg 1st press: 35min 2nd press: 10min	8.5kg 1st press: 35min 2nd press: 10min	8.5kg 1st press: 35min 2nd press: 10min	2hrs
10mm	11kg 1st press: 35min 2nd press: 15min	11kg 1st press: 35min 2nd press: 15min	11kg 1st press: 35min 2nd press: 15min	2hrs
12mm	12.5kg 1st press: 40min 2nd press: 15min	12.5kg 1st press: 40min 2nd press: 15min	12.5kg 1st press: 40min 2nd press: 15min	2:30hrs
16mm	17kg 1st press: 40min 2nd press: 15min	17kg 1st press: 40min 2nd press: 15min	17kg 1st press: 40min 2nd press: 15min	2:30hrs
20mm	22kg 1st press: 45min 2nd press: 15min	22kg 1st press: 45min 2nd press: 15min	22kg 1st press: 45min 2nd press: 15min	3hrs
30mm	33kg 1st press: 50min 2nd press: 20min	33kg 1st press: 50min 2nd press: 20min	33kg 1st press: 50min 2nd press: 20min	3:30hrs
40mm	44kg 1st press: 55min 2nd press: 25min	44kg 1st press: 55min 2nd press: 25min	44kg 1st press: 55min 2nd press: 25min	4hrs

The process :

- Sorting waste by type and color
- Shredding

- Mould preparation (two steel sheets + 1m x 1m frame) with silicone spray as release agent.
- The ground and weighed plastic material is placed in the mold.
- The mold is then placed in the heated press.
- After the heating and pressing cycle, the mold is placed under a cold press to maintain its shape during cooling.
- The plates are then prepared using a hand sander with different grits depending on the level of detail required by the customer, to achieve a smooth surface finish.
- The sheets are then cut, machined and assembled.

Here we can see modifications made to the molds to prevent the welds from breaking. An improvement that can be avoided if the welds are well made.



Heated Press + Press: the example of TRS (The Recycle Studio), the best-quality plates from the Precious Plastic ecosystem, Costa Rica

Olivia and Oliver from The Recycle Studio, whom we met during our stopover in Costa Rica, are considered to be the recyclers of the Precious Plastic ecosystem, producing the highest quality sheets. Below, we present the modifications they have made to Precious Plastic's initial designs:

[Video Precious Plastic : The ultimate guide to make the PERFECT sheet | 2024](#)

- Trays made of heat-resistant, thick-walled steel to prevent deformation over time and numerous heating cycles



- More rigid guide column



- Place the heating press on a railing so that it can be aligned with each cold press.



Heated press + Press: the example of Sungai Watch, plastic bag recycling, Indonesia

A young company based in Bali, Indonesia, Sungai Watch currently employs 120 people, and has installed over a hundred barriers in Bali's nearby rivers to collect plastic waste, which it then sorts and recycles.

Plastic bags account for a large proportion of the waste collected. Their activity is presented and detailed in a YouTube video from the Precious Plastic channel:

What they do with RIVER plastic is INSANE | SUNGAI WATCH



With their two heated presses, they recycle 300kg of plastic bags a day. The one-square-meter, 3cm-thick sheets weigh around 20kg and represent 4,000 recycled plastic bags. They began their recycling activity using an oven with a cold press, but the results didn't produce a finished product of sufficient quality, probably due to the low density of a pile of plastic bags.

With this type of waste, it seems much more appropriate to use a heated press to shape the bag at the time of heating. After installing the heated press + press line according to the Precious Plastic models, it took the Sungai Watch teams 1 month to reach the process settings required to obtain good-quality plates. With their current process, they have to shape their plates in two stages.

- The first pass through the heated press produces the plates shown in the photo on the left.
- A second pass through the press produces a much higher-quality plate, as shown in the photo on the right.



Making polyaluminum sheets: the example of Ecotex and Proplast in South America

Ecotex in Brazil and Proplast in Colombia are recycling companies that process polyaluminum waste. This waste comes from Tetrapak packaging, or packaging such as coffee bags, potato chip packets, etc. The polyaluminium mixture can be a PP/aluminium or LDPE/aluminium blend.

For example, a Brazilian corrugated sheet measuring 2.2m*0.9m*5mm weighs 14kg.

The shreds are deposited on a steel tray with a polyester film separating them from the steel. A multi-stage thermopress heats 5 plates simultaneously to a temperature of 130°C for 40 minutes. The polyester film prevents the plates from sticking to the press platens, as it does not melt or stick at 130°C.



The sheets are then moved to a corrugating press for 40 min. For a further 24hrs, they are cooled in the open air with the aid of a shaper.



Making plates with an extruder

Less common than the dies described above, it is also possible to produce sheets using an extruder.

Making plates with an extruder: the example of Ecolab8, Indonesia

Here, the plastic is extruded from the extruder and deposited on the bottom of the mold, where it is spread with a trowel. Once the mold has been filled, it is put back into the oven to homogenize the material before being returned to the press. This process produces a marbled visual appearance.

<https://www.instagram.com/p/CrVUzlGNzx1/?hl=fr>
<https://www.instagram.com/p/C3Ke1l9SNL5/?hl=fr>



Making sheets with an extruder: the example of IPS Madera Plastica, Costa Rica

IPS is a young Costa Rican company that mainly extrudes recycled HDPE/PP/PEBD profiles and boards. These boards come in a variety of sizes and cross-sections, and can be used to manufacture street furniture.

Over the years, they have tested various more complex molds at the output of their extruder. These include molds for making manhole covers, or even complete chair/bench supports.

Here are two examples:



Chair support mould/Bench



Mould for manhole cover with integrated sign

Liquid silicone is added to the inner surfaces of the mold. The mold is attached to the exit of the extrusion die. The extruder pushes the molten plastic into the mold. Once filled, the mold is cooled either in the open air or in a cooling tank.

Demolding :

For the chair/bench, the top plate of the mold is unmolded, along with the mold's 2 central straps. Thanks to the liquid silicone, the chair/bench support is easily demolded and ready for assembly.



For the manhole cover, the top plate is unmoulded, along with the strapping with the signs. The manhole cover is easily removed from the mould, already marked with the appropriate sign.



This extrusion technique is a great innovation for outdoor furniture. It eliminates the need to cut out the inside of a sheet, resulting in a lot of wasted off-cuts.

2. Treatment of cooled plates

Once the plates have cooled and come out of the cooling press or forming machine, a certain amount of work is often still required, whether to improve the quality of the plates themselves or to process them into finished products.

Works on surface finish and edges

Although it is possible to obtain extremely high quality plates from the cooling press, as TRS proves, it is often necessary to rework the plate edges and surfaces.

- Surface treatment :
 - at least remove traces of silicone
 - Sanding by hand
 - Sanding
 - Use of a grinding machine
 - Use a blowtorch to absorb surface bubbles

This finishing process is illustrated in the following video:

[Video Precious Plastic : How to recycle PLASTIC with a bread oven | ROBRIES](#)



- Working with sides and angles :
 - Band saws
 - Table saw
 - Jigsaw (for minor modifications)

Shaping and assembly techniques

It is also possible to work on the shape or surface of the plates, depending on their intended use:

- CNC or waterjet (computerized numerical control) cutting or surface finishing:
 - [Video Precious Plastic à TRS : They've CRACKED the recycling game](#)



- Plastic bending :
 - [How To de Precious Plastic : How to bend Plastic Sheet](#)
 - [How To de Precious Plastic : Make a chair with bent sheets](#)



3. Production tips for making recycled plastic sheets

Plate mold architecture

Plate molds can be made very simply by welding a frame which is then sandwiched between two metal plates. It is advisable not to weld the frame to one of the metal plates, to facilitate demolding.

As for the choice of material for the metal plates, a standard steel used with a silicone film seems to do the trick, such as A36 (American standard) and S275 (European standard).



Credit :

<https://community.preciousplastic.com/how-to/turn-a-pizza-oven-into-a-sheet-oven->

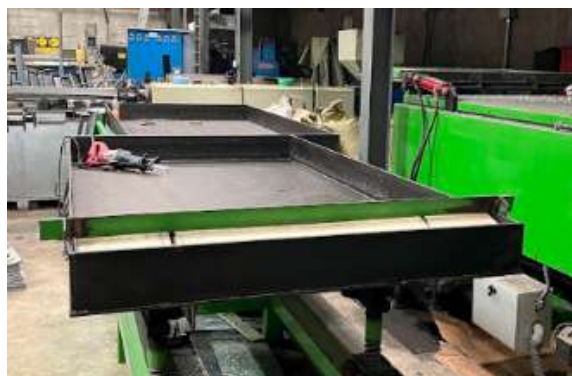


Credit : [Video Precious Plastic : How to recycle PLASTIC with a bread oven | ROBRIES](#)

Other plate mold shapes are also possible, as shown in the following example from Wedoo in Bali, Indonesia.



Another mold architecture is used by Capobianco with a die and punch. Here, the mold surface is painted.



Tips for achieving high-quality plates with a hot press

These tips are the fruit of feedback from Olivia and Oliver of The Recycle Studio, who are considered the producers of the best plates in the Precious Plastic ecosystem:

[Video Precious Plastic : The ultimate guide to make the PERFECT sheet | 2024](#)

The most important factor is the quality of the incoming material. TRS uses high-quality shredded material prepared by an external company, or even recycled pellets.

- **PS seems to be the plastic with the best rendering in plate form**, it is also central to the production of larger companies such as Le Pavé and Smile Plastics.
- It is not advisable to stack plastic sheets on top of each other during press cooling, among other things, to avoid releasing pressure.
- It is advisable to maximize compression cooling time (as a rough guide, count about 3 times the heating time).

- Stay as close as possible to melting temperature (180°C HIPS and 160°C HDPE).
- Apply the right amount of plastic, starting with 1g per cm³
- Repressurize every 10 minutes at most in the heated press

Setting example :
HIPS (high impact polystyrene)
¾ inch (19mm), 1000x1000mm, 19.2kg
72 minutes heating time
press cooling 210 minutes

This advice can sometimes be detrimental to the productivity of the production line, so it's up to each individual to place the cursor between production and quality.

Practical extras to make life easier

A number of pieces of equipment are available to facilitate the plate-making process. The design and layout of all equipment should also be carefully considered. For example, it's a good idea to place your preparation table, oven/heating press and cooling press at the same height, to facilitate mold transfer.

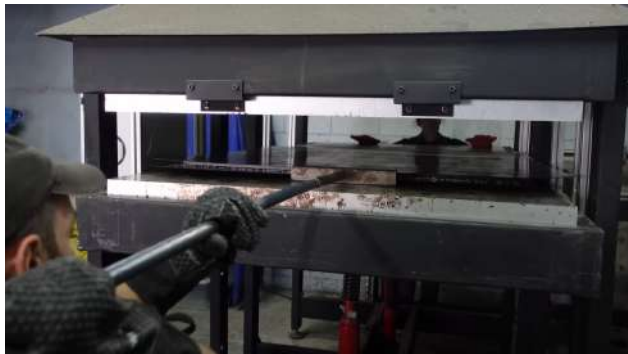
- Small test press: for roughing out the work, not using large machines in production, not using too much material, faster testing, thermal inertia due to volume
- Scale to measure the quantity of plastic put into each plate



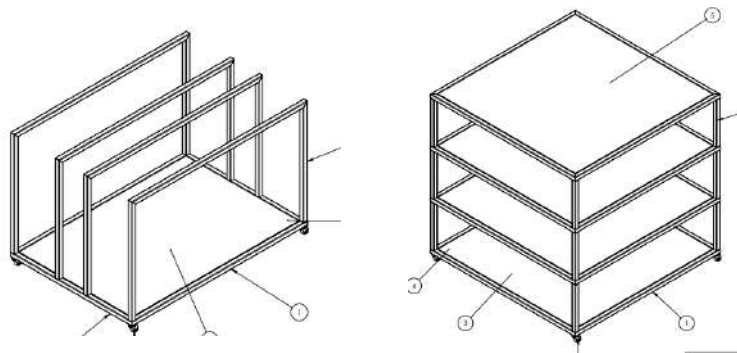
- **Silicone lubrication for mold extraction**



- Pizza stand



The Precious Plastic kit also includes plans for various pieces of furniture to help organize your workspace: a storage rack, a shelf for storing finished plates:



4. Possible outlets for these ecological boards

There are two options: on the one hand, you can concentrate on the manufacture of recycled plastic sheets, or on the other hand, you can also include in-house the carpentry steps leading to the creation of a finished product that can be used as such.

Semi-finished product: Who can I sell recycled plastic sheets to?

As recycling operations are time-consuming and require real know-how, it is sometimes preferable to concentrate on this trade and resell the boards to other companies who can use them as raw materials in their creations.

For example, TRS (The Recycle Studio) in Costa Rica has developed a range of boards with different colors and properties, which they then sell to interior designers and architects. However, this requires very high quality boards with a very fine finish.



Planks as such, without any additional work, don't find much use, except perhaps as formwork plates in the building industry. In such cases, the same expectations are not placed on the quality of the boards in question. Where surface finish and color mix are paramount for a plate used as a raw material for luxury furniture, durability and mechanical characteristics will be important factors in a building application. **Reform Plastic** in Vietnam has explored these two completely different markets.



Finished product: What to do with recycled plates

Depending on the quality of the sheets obtained, a joinery job can be used to create multiple finished products. Examples include :

- Outdoor furniture
- Indoor furniture
- Shower enclosures
- Trophies
- Skateboard
- etc...

The question then arises of distribution.

You can either sell directly to private individuals (B to C), via a showroom/boutique, a website or directly via a personal address book.

Or sell to other businesses (B to B), via furniture boutiques, directly to hotels, restaurants, corporate offices, municipalities, etc...

Examples of companies and finished products around the world

To continue reviewing the field of possible engineered products. Below you will find links to several companies working on the recycling of plastic in sheet form:

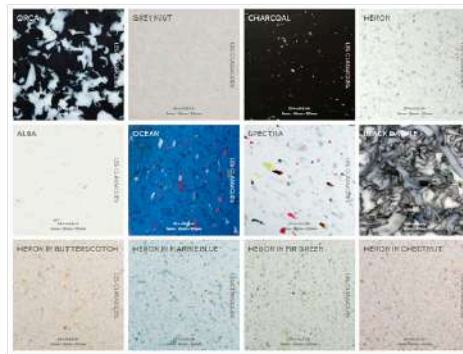
To begin with, we'd like to introduce three industrial companies based in Europe that have developed their own production lines for large-format sheets. Their sheets are of excellent quality, and these companies have already completed numerous projects:

Smile-Plastics

United Kingdom



Alba 20mm, Lobe Berlin.
By Plural Studios



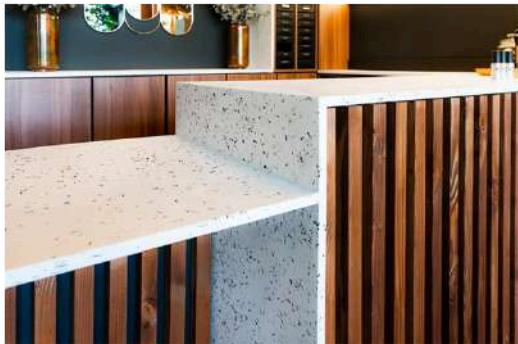
Echantillons



Matériau HIPS sur
mesure
By Holt Renfrew

Le Pavé

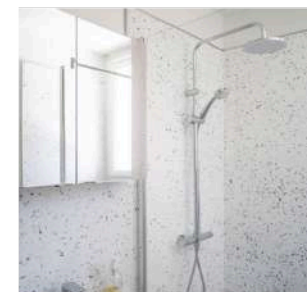
France



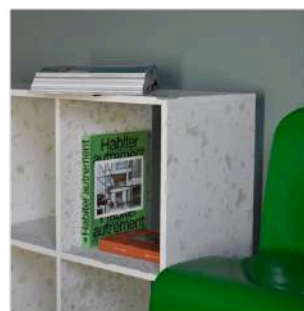
Comptoirs Julie Optique



Table panneau PS



Douche panneau PEHD



Meuble 4 cases PS

The Good Plastic Company

Netherlands and Ukraine



Porte-manteau



Le contour de terrain de l'EGAR



Librairies d'Iryna Tsyoma et Ole Storjohann

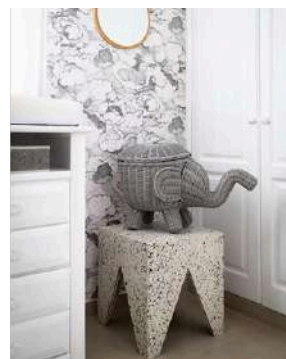
There are also other companies with output products that are not sold as luxury goods and that offer a different vision and outlets in their recycling business:

Capobianco Soluciones

Dominican Republic



Bac poubelle extérieur



Rinnovarestudio "MARA"



Bac poubelle porte frontale

Reform Plastic

Vietnam



Coffrage



Bacs poubelles de tri selectif



Table d'école

Cedar Environnement

Lebanon



Composteur



Ligne de tri de Beit Mery Recycling Facility



Fermes verticales

Then there are the many projects in the Precious Plastic ecosystem offering a wide variety of finished products:

Precious Plastic Community

World



Plastique Factory BE



Tabouret pied en panneau plastique, Plastplan



Tabouret avec pieds en bois, Still Life

TRS (the recycle studio)

Costa-Rica



Meuble de douche



Porte savon



Bodega - Duo Cabinet

Onka

Costa Rica



Smaller Surfboards
Designed specifically for pumps and curves

Eco Trofeos

Dominican Republic



Cadre diplôme



Médailles

Trophée



Carbon Blue

France



Fourmis décoratives

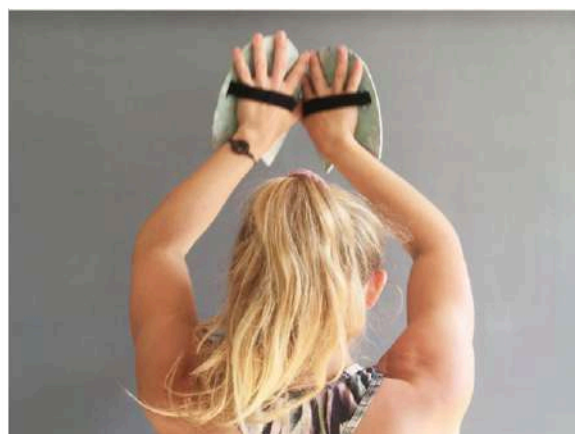


Fauteuil et table basse d'extérieur MISTRAL

Merijian
Germany



Supports muraux planche de surf



Plaquette bodyboard

Metamorphica Lab

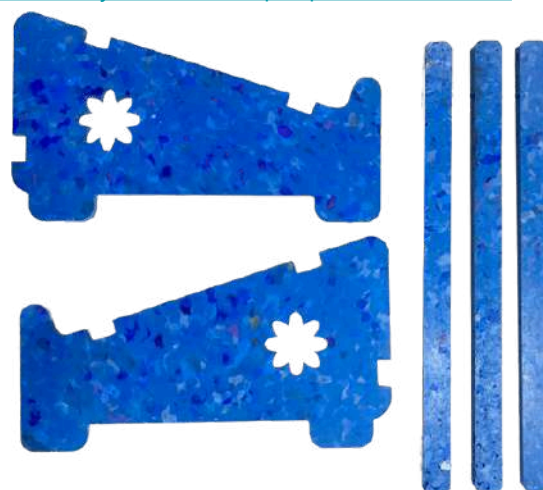
Colombia

Blueprints:

<https://community.preciousplastic.com/how-to/make-your-own-laptop-stand-59390>



Supports d'ordinateur



Eléments avant assemblage

Conclusion

In conclusion, our in-depth study of the different production processes for recycled plastic sheets offers us a comprehensive overview of the challenges and opportunities in this crucial area of plastics recycling. By exploring methods such as the oven + press, heated press + press, and extrusion approaches, we gain a better understanding of the technical implications of each process.

Looking at examples from companies around the world demonstrates the diversity of applications for recycled plastic sheet. Whether as a semi-finished product sold to other companies or as a finished product for the consumer market, the outlets are vast and varied.

The emphasis placed on quality and innovation, as demonstrated by companies such as The Recycle Studio in Costa Rica and the European companies mentioned, underlines the importance of the constant quest for improvement in manufacturing and recycling processes.

Last but not least, this guide is intended to be evolving and collaborative. We encourage feedback and contributions from all industry players to enrich and continually improve our plastics recycling practices. Together, we can transform environmental challenges into sustainable opportunities for the future of our planet.



It's now up to you to take this knowledge and apply it to the environment around you.