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Guide to Recycling

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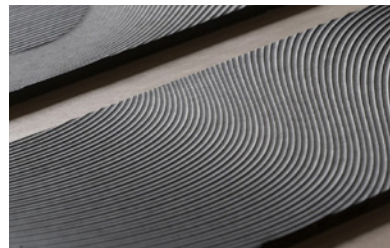
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INTRODUCTION

We tend to have a fairly simplistic understanding of recycling – as in materials from recovered products being used to make more products of the same kind – but recycling actually covers a wide range of processes that can change materials beyond recognition along the way.

While the aim of some recycling certainly is to make more products of the same kind – think of plastic bottles and aluminium cans, for example – it's often difficult to separate different kinds of waste and avoiding contamination, which makes design for disassembly a very important factor in recycling. Products that are difficult to take apart cannot be processed by recyclers and as a result materials are often downcycled, if recycled at all.

In this context, it's also important to be clear about the origin of recycled materials – there is often a very big difference in the amount of logistics and processing needed for post-industrial and post-consumer recycled materials, which of course has an immense effect on the environmental impact of materials. Several certificates exist to validate the authenticity of recycled materials, such as SCS Global Services Recycled

Content, which covers a wide range of materials, as well as certificates for specific material categories, such as FSC and PEFC certification for recycled paper and timber products and the Global Recycled Standard (GRS) for textiles.

Post-industrial recycling (PIR)

Recycling of waste that is the result of materials and product manufacturing. In some cases, such as plastics and metals, post-industrial recycling is very common, while for other materials, such as ceramics, it hardly happens at all.

Post-consumer recycling (PCR)

Recycled waste from products that have been recovered from consumers. Compared with post-industrial recycling, this is often quite a complex process, both logistically, but also in terms of

separating different kinds of waste, cleaning and other processing.

Closed loop recycling

A collection scheme for specific products that are recycled to make more of the same product, such as drinks bottles and cans. As Extended Producer Responsibility (EPR) schemes are introduced in different markets, closed loop recycling should also become more common.

Upcycling/downcycling

While the term upcycling is often used to describe how recycled materials from a low value application, such as packaging, is used in something with higher value, such as furniture, you could argue that any recycled material that cannot be used in the same application it originally came from is, per definition, downcycling.

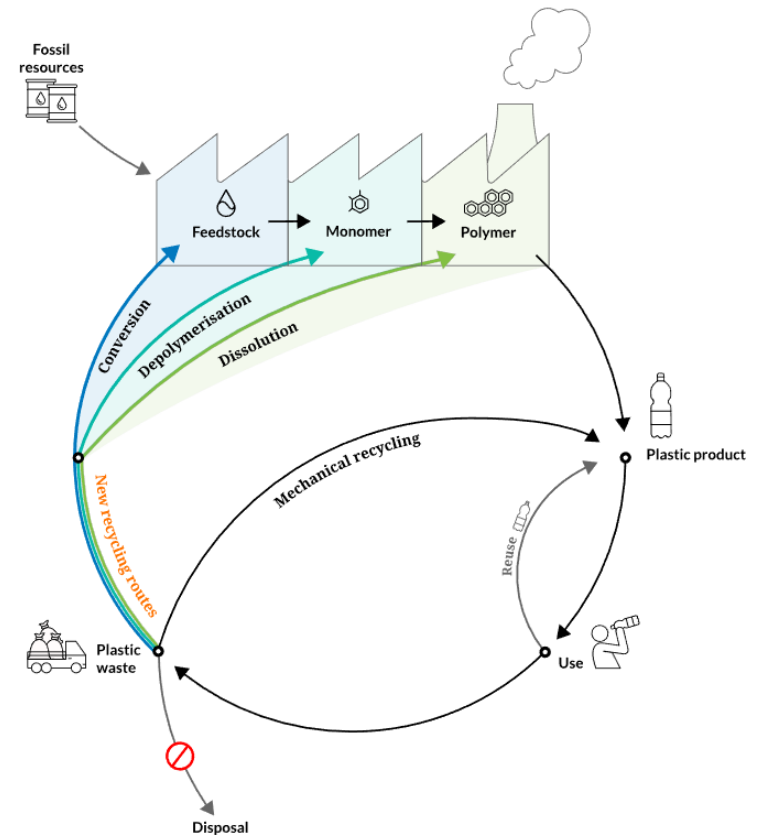
This report aims to bring clarity to the processes that are used for recycling some of the most common materials in product design today, as well as sharing insights for how to use recycled materials more efficiently and ensuring that recycling continues to improve in the future.

Plastic recycling

Plastics are incredibly versatile – from rigid and strong plastics for structural parts, to thin films and elastomers that can go into all kinds of soft and flexible applications. In addition to raw materials, a very wide range of additives are used for aesthetic purposes such as adding colour and special effects, as well as additives to give plastics all kinds of functional enhancements such as anti-static properties, fire- and UV resistance, to name just a few examples.

While this flexibility makes it possible to create highly specific and efficient plastics for almost any application, unfortunately it also makes plastic recycling quite difficult. In fact, it is estimated that only about 9% of plastics are recycled globally. One reason is that so-called mechanical recycling, the most common plastic recycling process available today, requires different types of plastic to be separated before recycling. In response to these shortcomings, several alternative plastic recycling processes are being developed to enable better quality materials and higher plastic recycling rates overall.

¹ A diagram by CEFIC, the European Chemical Industry Council, outlining the main plastic recycling routes available today



1 Plastic recycling routes

Mechanical recycling

The vast majority of plastic materials in use today are so-called thermoplastics, which is just a fancy name for plastics that become soft and mouldable when they are heated up. This process is repeatable, meaning that plastic waste can be shredded, melted and re-formed into new products, which is essentially how mechanical recycling works.

While this process is simple in theory, the many different plastics that are widely used makes recycling rather difficult. Mixing plastics during recycling will typically lead to materials with unpredictable performance, so different plastics should be separated. Additives are also an issue – mixing different colour plastic waste will lead to recycled materials with a blend of all colours that went into it. Typically, recyclers add black or dark grey pigment to cover any colour inconsistencies.

All of this means that plastic waste needs to be sifted through, separated and cleaned very carefully to enable high quality mechanically recycled plastics. Alternatively, less carefully sorted waste often downcycled into garden furniture, building insulation and other applications with less stringent requirements. Lastly, most plastics can only be mechanically recycled a handful of times before the material is degraded to a point beyond usefulness. For these reasons, it can be challenging to source mechanically recycled plastics. But large scale plastics recycling is still a fairly recent development and new approaches and improvements come along all the time. Several suppliers are developing mixed waste recycled plastics that might pave the way for new ways of thinking about plastic waste and how to design with recycled materials.

- 2 Logitech's Lift mouse uses mechanically recycled ABS for the outer cover
- 3 The Chap stool by Vitra is made with mechanically recycled polyamide
- 4 Microsoft's Ocean Plastic mouse is made with a blend of polycarbonate and mechanically recycled PET from bottles



2 Logitech Lift mouse



3 Vitra Chap stool



4 Microsoft Ocean Plastic mouse

Chemical recycling

Chemical recycling is actually several different processes. To understand how it works, it helps to know a little about how plastics are made in the first place. Hydrocarbon feedstocks such as naphtha and natural gas are the fundamental chemical ingredients in plastics. These feedstocks are then further refined into so-called monomers, which are the molecular building blocks of all plastics. And finally, a chemical chain reaction turns monomers into polymers, which is just another word for plastic.

Chemical recycling processes exist for converting plastic waste back into polymer-, monomer- and feedstock state. So-called dissolution removes functional and aesthetic additives from plastic waste to generate recycled plastic with equal performance to virgin material. Depolymerisation breaks down plastic waste into monomers, which can then be used to make any type of plastic that use these specific monomers. And lastly conversion processes convert plastic waste into feedstock that can be used to make any type of plastic, regardless of the type of recycled plastic waste.

Chemical recycling doesn't require the same level of cleaning and separation as mechanical recycling. With some depolymerisation and conversion processes it is even possible to recycle different types of plastic waste together without separation. On the downside, at least for now, chemical recycling is very energy intensive, meaning that the carbon footprint of chemically recycled plastics is typically only marginally lower than virgin plastics.



5 Philips Eco Conscious blender

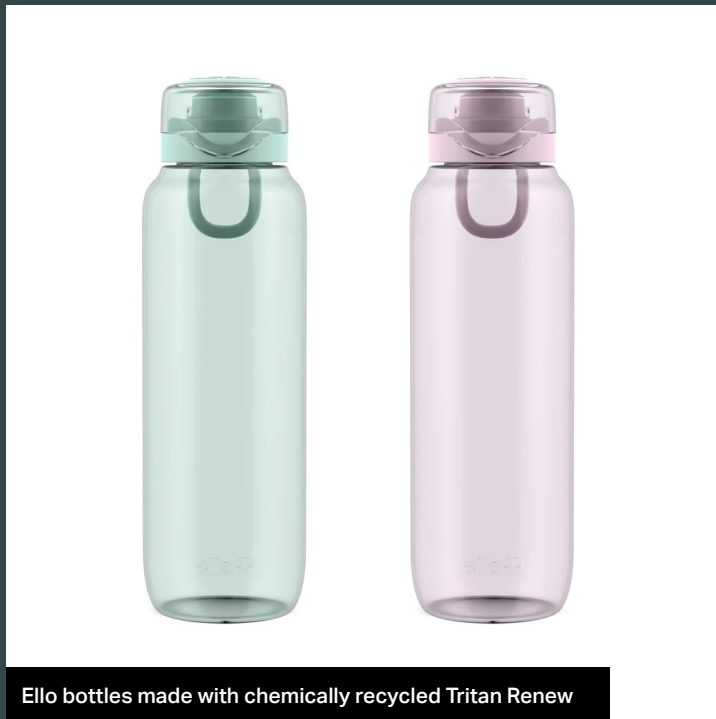


6 EC3D soap dispenser

- 5 The clear container in the Philips Eco Conscious blender uses Tritan Renew, a co-polyester partly made with chemically recycled PET
- 6 EC3D soap dispenser made with chemically recycled polypropylene
- 7 The Perch stool from Steelcase is made with chemically recycled polyamide from BASF



7 Steelcase Perch stool



Ello bottles made with chemically recycled Tritan Renew

ONE TO WATCH

Eastman

The US-based plastics supplier Eastman is at the forefront of chemical recycling of plastics, having developed several processes. Its Carbon Renewal Technology is a conversion process for recycling mixed plastic waste back into basic feedstock that can be used to make any kind of plastic material, while the company's Polyester Renewal Technology is a depolymerisation process for polyester-based plastics such as PET back into its monomer building blocks, which can then be used to make more polyester-based materials, such as Tritan Renew.

Key concepts in plastic recycling

Colour and recycled plastics

Colour and opacity in plastics is a bigger challenge than you may think in plastic recycling. Unless plastic waste is meticulously sorted by colour and opacity during the mechanical recycling process, the result will be a recycled material that is an opaque blend of the colours that went into it. The only remaining options in terms of colour is to keep it like that, or adding black or dark grey pigment to cover colour inconsistencies.

Mixed plastic recycling

New blends and plastic combinations are emerging as plastic recycling becomes more widespread, with the benefit that they typically require less careful sorting and make it possible to recycle larger volumes of plastic.

Monomaterial

Different types of plastics are often combined to provide different properties and aesthetics, but this makes separation and recycling difficult. As an alternative approach, consider using a single material for the entire product or assembly. Many plastics are versatile enough to provide a wide range of functions and aesthetic expressions, which makes plastics recycling much simpler.

Act now

Plastic waste is a global problem that puts enormous strain on the environment. As designers, we need to think differently about how we design with plastics and what happens to the material at the end of life of plastic products.

- The colour and transparency of plastic waste play a larger role in recycling than what you may think. Transparent materials are more valuable to recyclers, so consider adding colour to products and packaging in other ways than in the form of pigments in the plastic itself
- The number of different plastics that are widely used means that a lot of effort needs to be put into separating them before recycling. Consider using common commodity plastics rather than more rare engineering plastics if possible at all. If possible, design products entirely with a single material, rather than combining several different materials.
- Plastic recycling is rapidly changing. Be sure to keep up with improvements to mechanical recycling processes and time and emerging technologies such as chemical recycling.

- 8 The Evolve chair by London-based designer Tom Robinson is made with recycled electronics waste from the Dutch supplier The Good Plastics Company
- 9 The Concept Shoe is a project set up by Salomon to recycle TPU materials from running shoes for use in ski boots

8 Evolve chair by Tom Robinson



9 The Concept Shoe by Salomon

Textile recycling

Given the huge volumes of textiles that are used in the fashion industry and in other applications that use textiles, it is remarkable how little of it is actually recycled. In fact, many 'recycled' textiles are actually made with other recycled materials and products, such as bottles and fishing nets, rather than actual recycled textiles. There are several reasons for this – while in principle textile recycling can be as simple as taking a piece of discarded textile and cutting it into smaller pieces that can be joined into new products, this approach is not very flexible.

Opening up for a wider range of recycled textile applications is more complex and involves extracting and re-spinning the yarn in discarded textiles so that it can be woven into new fabrics. It also doesn't help that many textiles consist of blends of different types of yarns, making recycling even more difficult. Over the following pages we take a closer look at different approaches to textile recycling and their relative strengths and weaknesses.

10 Wool textile waste at Cardato, one of the many textile recyclers in Prato, Northern Italy, an area with a long history of textile recycling



10 Cardato

Textiles from other recycled materials

More than half of the amount of textiles that are produced globally are synthetic textiles, with polyester being the textile material produced in the largest volumes. Polyester is just another name for PET, the plastic material that is widely used in plastic bottles, as well as other plastic packaging and products. This means that discarded bottles and other PET waste can be ground down and extruded into filaments for polyester textiles. The same process is applicable to other plastic waste that can be made into synthetic yarn, such as polyamide, or nylon, which is what it is usually called in textile form, as well as polypropylene and stretch fabrics such as elastane.

This gives a lot of flexibility to use a variety of waste streams and materials for textile production, and several suppliers, including Unifi, one of the largest suppliers of recycled polyester textiles, make targeted efforts at collecting plastic waste that would otherwise end up in the open environment and the world's oceans. But this approach does less to address the key issue of low recycling rates of textile waste, meaning that it should be seen as a part of the solution of more circular and sustainable textiles in the future, rather than the whole solution.



11 Pacsafe Camsafe backpack



12 Bottle to textile process

13 Vescom polyester textile made with rPET



- 11 Pacsafe Camsafe backpack made with recycled polyamide (nylon)
- 12 PET bottle to polyester textile process
- 13 Polyester textiles made with recycled PET from the Dutch supplier Vescom

Recycled textiles

While most textiles recycling today is using other waste from outside the textile industries, as described in the previous section, textile recycling was actually common in the past, when access to virgin raw materials was much more limited and expensive. Recycling of woollen textiles has a long history in the area around the city of Prato near Florence in Italy. In fact, wool is probably the most widely recycled textile currently and used in everything from fashion to furniture and consumer electronics. But there are also several emerging recycling processes that take actual textile waste as

the raw material. Some of these use chemical recycling processes that essentially dissolves discarded textiles to extract fibres that can be re-spun into yarn, such as Circulose from the Swedish supplier Renewcell, using a process that makes recycled viscose using cotton textile waste. But there are also mechanical recycling processes such as Texloop recycled cotton from the LA-based supplier Circular Systems. And beyond woven textiles, suppliers are developing processes for non-woven materials such as leather, including the UK-based supplier ELeather.

- 14 The textile front cover of the LG Cinebeam projector is made with Re-wool, a recycled wool textile from the Danish supplier Kvadrat
- 15 The textile speaker cover in the NoBounds portable speaker by Marley is made with a blend of recycled cotton and other textile fibres
- 16 Kibo sneakers with a recycled leather upper



14 LG Cinebeam projector



15 Marley NoBounds speaker



16 Kibo sneakers



ONE TO WATCH

Sysav Refab

Sysav started in the 1970s as a waste management company handling household and industrial waste in the south of Sweden. Since then, it has grown into a major recycler in the region and in 2020, Sysav opened the world's largest automated sorting facility for textile waste. This makes it possible to quickly and accurately process large quantities of textile waste by fibre type and colour, which is then bundled together and supplied to textile recyclers such as Renewcell and Recover that further process the waste into different types of textiles.

'Recycled' vs. 'recyclable' textiles

Perhaps more than other materials, the meaning of 'recycled' and 'recyclable' is crucial in the context of textiles. Currently, most recycled textiles are made with waste from other industries, such as plastic packaging or fishing nets, while actual textiles are hardly recycled at all.

Mixed fibre textiles

Many textiles consist of combinations of different textile fibres for improving the durability, comfort and aesthetics of the material. Mixed fibre textiles make recycling difficult, however, so consider using textiles that are made with a single type of fibre, if possible.

Colour and textile recycling

Like many other materials, such as plastics, glass and paper, once colour has been added to textiles, it's not easy to remove again. Evaluate whether your textile application needs added colour in the first place and consider using light colours if possible, as this makes it possible to overdy textile fibres after recycling.

Act now

It's estimated that some 110 million tonnes of textiles are produced globally on an annual basis. Yet only a fraction of these textiles are recycled. We need to change the way that we produce and use textiles, and improved recycling rates will play a big role in the solution.

- Be clear about what kind of 'recycled' textiles you are specifying. Currently, most recycled textiles are made with waste from other industries, which is not helping improving the recycling rates of textile waste
- Mixed fibre textiles makes recycling complicated. Use textiles that are made with a single type of textile fibre if possible
- On the other hand, textile recycling can also be as straightforward as cutting textile waste to shape for use in new products

- 17 The Swedish fashion brand Monki used textile waste that has been cut down to size to be used as patchwork textiles in the Upcycle collection
- 18 This tote bag from Mini Rodini is made with leftover textiles from the brand's other products



17 Monki Upcycled collection



18 Mini Rodini tote bag

Metal recycling

Currently, metals are among the most widely recycled materials globally. This is partly because of the high value of metals, which also makes recycling economically viable, but also because it's relatively easy to separate metal from other types of waste. Metals also have an inherent advantage in that they can be infinitely recycled with only minimal process waste and loss of properties. On top of this, most metal surface treatments and coatings do not negatively impact recyclability, as they are typically burnt off during the recycling process as the metal is melted down again.

The downside is that while recycled metals require considerably less energy to produce compared with virgin materials, metals processing, including forming and finishing, still requires a lot of energy. But put to good use in the right application, metals can have an exceptionally long life and very likely look forward to being recycled when metal products are discarded. To use aluminium as an example, the International Aluminium Institute estimates that 75% of the aluminium that has ever been produced is still in active use today.

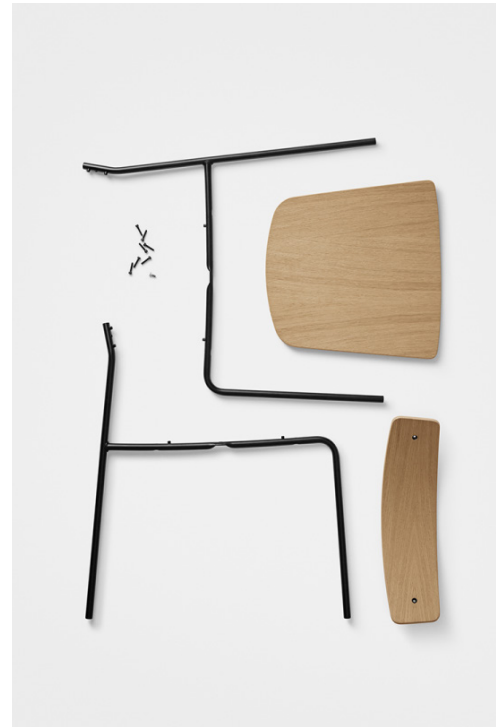


Recycled steel

Compared with recycling most other materials, steel is relatively straightforward and inexpensive to separate from other waste because it's magnetic, meaning that steel can simply be pulled out using powerful magnets. Once separated, the steel is melted down in a process that will also remove any surface treatments, coatings and paints, and further processed into a variety of recycled steel materials.

Several steel suppliers offer steel materials with a high ratio of recycled content, including Bluemint Recycled from Thyssen Krupp. Recycled steel can be used in everything from furniture and accessories to construction and industrial applications, but because it easily corrodes it typically need some kind of coating for protection.

For applications that require a higher degree of corrosion resistance, stainless steel could be a better alternative. Stainless steel is made by alloying steel with other metals, such as chromium, manganese and nickel, which gives the material corrosion resistance, but also an exceptionally hard and durable surface. The Finnish supplier Outokumpu offers a range of stainless steel materials with a recycled content ratio of at least 90% that are used in everything from cookware to automotive applications.

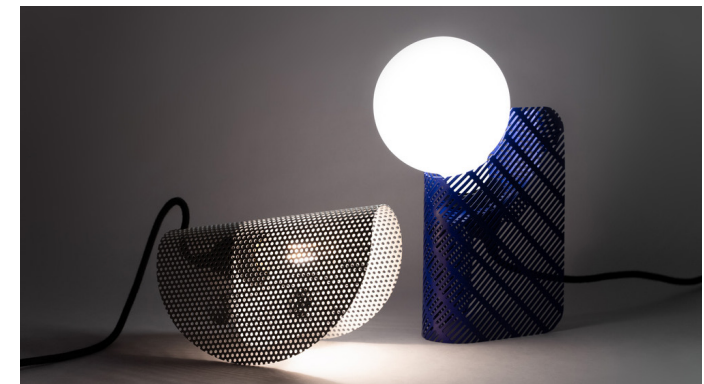


19 Takt Cross Chair Tube



20 Stilride e-scooter

- 19 The structural tubes in the Takt Cross Chair Tube is made with recycled steel
- 20 Stilride e-scooter made with folded recycled stainless steel sheet
- 21 Circular Dept. Store lights by GoodWaste, made with recycled steel store fittings



21 GoodWaste Circular Dept. Store lights

Recycled aluminium

Unlike steel, aluminium is a non-ferrous metal and therefore not magnetic. So rather than magnets, the electric current from a so-called eddy current separator is used to repel aluminium and other non-ferrous metals from other waste. In addition to this first round of separation, different aluminium alloys also have to be separated, as the type of alloy will have a huge impact on compatible forming processes and finishes.

This makes sourcing recycled aluminium a little complicated, as different recyclers often specialise in specific alloys. For example, the Norwegian supplier Hydro offers aluminium with a high recycled content for extrusion, while global aluminium supplier Novelis specialise in sheet materials, and yet other suppliers such as Stena Metal in Sweden and Raffmetal in Italy offer recycled aluminium alloys for casting. The performance of high quality recycled aluminium is very similar if not identical to that of virgin material, but small defects can sometimes be visible in the surface of recycled aluminium, especially in light colour anodised and polished natural aluminium parts.



22 Stumpastaken candle holder

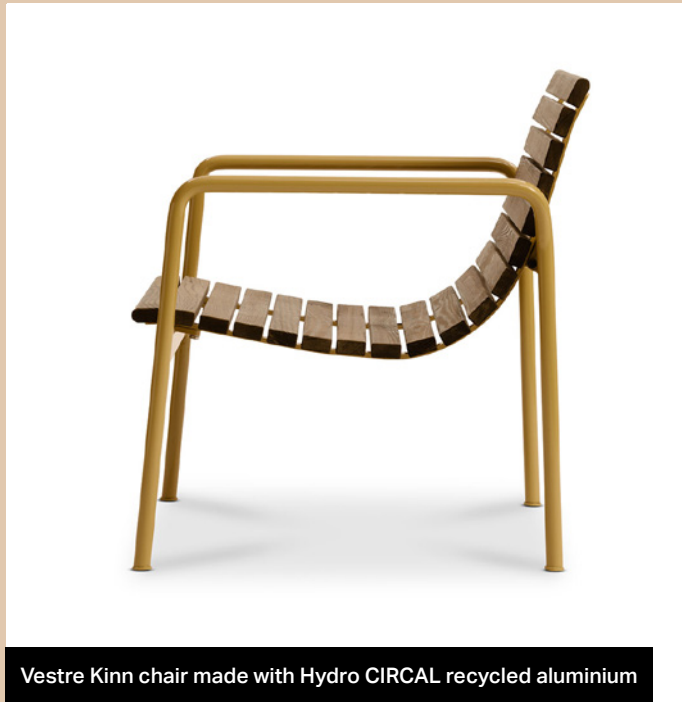


23 Samsung TV

24 Hem T-Shelf



- 22 Stumpastaken candleholder made with recycled cast aluminium
- 23 Samsung TV made with recycled aluminium sheet from Novelis
- 24 T-Shelf by Hem made with Hydro RESTORE, a mix of post-industrial and post-consumer recycled aluminium for extrusion



Vestre Kinn chair made with Hydro CIRCAL recycled aluminium

ONE TO WATCH

Hydro

Hydro CIRCAL recycled aluminium for extrusion applications from the Norwegian supplier Hydro contains 75% post-consumer recycled content, the highest of any comparable material currently available in the market. The material is compatible with common aluminium finishing processes, such as anodising and powder coating, or it can be polished and used with its raw, natural finish.

Other materials from Hydro include Hydro RESTORE, a mix of virgin aluminium with post-industrial and post-consumer recycled scrap, and Hydro REDUXA, low carbon virgin aluminium.

METAL RECYCLING

Key concepts in metal recycling

Energy efficiency

Metal recycling uses much less energy than virgin material production, but metal processes still tend to be rather energy intensive. Try to balance the energy that goes into making metals by putting them to good use in products with a long lifespan and simplifying disassembly and recycling on disposal.

Non-renewable raw materials

The various minerals that are used as raw materials in virgin metal production are non-renewable, so recycling helps with preserving these resources.

Reuse vs. recycling

Reusing products is always more efficient than recycling and few materials can compete with metals when it comes to potential for repairs. Metal surfaces that are slightly damaged through scratching or corrosion can often be touched up and polished so that they look as good as new, rather than throwing away the product. Dents and bumps can often be gently pushed or hammered out.

Act now

In terms of high recycling rates, metals are in a relatively good place, but we still need to recycle more metals to reduce the need for extracting non-renewable raw materials and the enormous amounts of energy that goes into the production of metals globally.

- Explore what recycled metals are widely available, as this may differ considerably from virgin materials, especially in the case of aluminium. Consider using a different type of material, alloy, forming or finishing process if these are a better fit with available recycled materials
- Using recycled materials is a good opportunity to rethink material requirements in general. Sometimes high performance metal materials are used in applications where lower specs would suffice. The same goes for finishes – could wax polished raw metal surfaces be an alternative to energy and resource intensive coating processes like plating, anodising and powder coating?
- Sometimes metals with a high recycled content have visible 'defects' in the surface. Instead thinking of this as a weakness, what are the ways that visibly recycled materials could be celebrated?

25 Polestar 0 is an attempt to manufacture the world's first carbon neutral car, in collaboration with suppliers such as Hydro and Ovako for recycled metals

26 Vitra Landi chair made with recycled aluminium



25 Polestar



26 Vitra Landi chair

Glass & ceramics recycling

Glass and ceramics are often lumped together because they use similar mineral raw materials in their production. But despite their similarities, there are big differences when it comes to recycling rates – while glass is among the most widely recycled materials today, it's a very different story with ceramics. Several recyclers are developing innovative processes for ceramics, however, so more ceramic waste may be recycled in the future.

Overall, increased recycling is crucial for securing the long term sustainability of the glass and ceramics industries. Illegal mining of common sand, which is an important ingredient in ceramic materials like concrete as well as glass, is endangering beaches and river deltas around the world, for example. At the same time, it's estimated that about a third of the world's combined waste on an annual basis consists of construction waste, of which ceramics and glass make up a very large part in the form of building waste from demolished buildings and industrial waste from the construction materials industry.

27 Various construction waste used by StoneCycling, a Dutch supplier of recycled bricks



27 StoneCycling

Recycled glass

The most common type of glass today is so-called soda-lime glass, which is used in everything from packaging, and tableware to windows. But there are big differences in how much glass from these applications that is recycled. Currently, packaging glass in the form of bottles and jars for drinks and food is by far the most widely recycled type of glass., whereas flat glass from windows and cars is recycled to a much smaller extent. This is mainly because there are fairly stringent rules about what kind of colourants, coatings and other additives that can be used in packaging glass, enabling closed-loop recycling of this category of glass. Additionally, just like plastics, colour needs to be taken into account with recycled glass. Once colour has been added to glass, it cannot be taken out again, although some over dyeing is possible to subtly tweak the existing colour of glass.

Other types of soda-lime glass from tableware, furniture and accessories such as lighting, as well as window glass and automotive often use coatings and laminated films, making these materials more difficult to recycle. Other types of glass, such as borosilicate glass used in Pyrex cookware, is available from specialist recyclers, while recycling of special glass like glass ceramics and aluminosilicate glass, such as Gorilla Glass commonly used in display covers in consumer electronics, is very rare currently.



28 Retap bottle



29 Common Sands Forite tiles



- 28 Retap bottle made with recycled borosilicate glass
- 29 Common Sands Forite tiles made with recycled glass from microwave ovens
- 30 Zara Home recycled glass tableware collection

Recycled ceramics

Although currently not as established as glass recycling, ceramic recycling does have a long history – terrazzo materials, essentially pieces and fragments of solid stone waste set in mortar, is known since ancient Egypt. The Chinese design studio Bentu used the same principle for their Wreck collection of furniture, using crushed waste porcelain tableware from the ceramic manufacturing hub Chaozhou in southeast China.

The excellent durability of ceramic materials also means that there are many opportunities for reuse – a brick in good condition could be taken out of a demolished building and put back into a new one, for example. On the same theme, Austria-based Studio Mixtura took used ceramic tableware and re-glazed it using recycled minerals from the Dutch supplier Mineralz to give it new life.

Yet another approach to ceramic recycling pioneered by the Dutch supplier StoneCycling takes offcuts and dust from the ceramics industries, as well as ground up post-consumer ceramic waste to create clay that can be moulded into bricks and other ceramic products. Ceramic dust can also be sintered, which is a process that uses heat and pressure to form solid sheet materials similar to slabs of natural stone. Several suppliers of sintered stone materials, including Cosentino and Idylium, offer materials with recycled content.



31 Studio Mixtura



32 Dekton Capsule collection

- 31 Reglazed tableware by Studio Mixtura
- 32 Dekton Capsule collection by various designers for Cosentino
- 33 Wreck furniture by Bentu made with ceramic waste from tableware manufacturers in Southeast China



33 Bentu Wreck furniture



ONE TO WATCH

Alusid

The UK-based start-up Alusid are the inventors of SilicaStone, a process for making ceramic sheet materials from recycled ceramics and glass. Ceramic waste in the form of powder and particles is mixed with molten glass waste to form solid sheets that can be used as a direct replacement for virgin ceramic sheets and tiles in a wide range of applications.

SilicaStone materials never use less than 98% recycled content and raw material sources include post-industrial recycled ceramic waste and recycled glass waste from road markings production and other sources.

Key concepts in glass & ceramics recycling

A global waste problem

It is estimated that fully a third of global waste is made up of construction waste from demolished buildings and industrial waste from the construction material industries. A very large proportion of this waste is ceramic and glass. This mountain of waste is a valuable resource that is currently mostly landfilled.

Reuse vs. recycling

Ceramic and glass recycling is energy intensive so consider giving discarded ceramic and glass products a new life through reglazing and dyeing. The Dutch suppliers Mineralz specialise in ceramic glazes made with recycled minerals from post-industrial and post-consumer waste streams.

Non-renewable raw materials

The raw materials that are used in ceramics and glass production are almost always non-renewable, and in some cases vital resources like common sand is running out as a result of illegal mining. Given that huge amounts of ceramic and glass waste is routinely landfilled, there is huge potential for recycling to reduce the need for virgin raw materials.

Act now

With the exception of packaging glass, ceramics and glass make up a very large part of the waste that is landfilled around the world on an annual basis. These waste materials are a valuable resource that could be put to much better use.

- Ceramics and glass recycling is crucial in reducing the use of non-renewable raw materials like natural stone, sand and clay in virgin material production. New recycling processes are emerging, so keep a close eye on developments for recycled materials that may be a good fit for your application
- Recycled ceramics and glass materials may not be identical to virgin materials, so adjustments to your design and application may be needed
- Beyond material types, ceramic and glass finishes typically also use non-renewable resources and considerable energy during application. Look for alternative finishes, such as recycled minerals for glazing

34 Ferm Living Oli glassware
made with recycled glass

35 Contrasti collection by
Moreno Ratti for Matter
of Stuff made with offcuts
from marble suppliers in the
Carrara area in Italy



34 Ferm Living Oli glassware



35 Contrasti by Moreno Ratti

Paper recycling

Besides steel, aluminium and glass, paper is one of the most widely recycled materials in the world today. And its importance and usefulness is only likely to grow in a wider range of applications going forward. For example, while poor moisture resistance has always been something of an Achilles heel for paper, new water- and grease-resistant coatings have been developed that do not impact the recyclability and biodegradability of the material.

But paper is waste also becoming an important source of raw material for other materials altogether – recycled cellulose fibre, the basic building block of paper, can be used in the production of everything from textiles to composite materials for a wide range of new applications that are set to fundamentally change our conventional understanding of paper materials.



Paper recycling

Paper recycling essentially breaks down paper waste into cellulose fibre by shredding and submerging it in water until it becomes pulp, which can then be formed and dried to form sheet and board materials, as well as moulded pulp. The type of recycled paper is often visible in the recycled paper material – depending on the recycling process, paper waste may be de-inked and bleached, but often it is not, with the result that it is often possible to see bits of old newsprint in paper pulp mouldings that are made with recycled newspapers, for example.

The recyclability of paper should also be taken into account. As mentioned earlier, paper has poor moisture resistance, which means that paper-based packaging and other applications that come into contact with liquids typically consist of a composite structure using paper combined with plastic films and metal foils, which are difficult to recycle. But a new generation of paper coatings are being developed that do not negatively impact the recyclability and biodegradability of paper, such as the paperboard material from the paper mill Stora Enso that is used in an all-paper ice cream tub from Carte d'Or. Similar developments are happening in the area of sealing and adhesives, such as the materials in a newly launched heat sealable paper pouch by Ritter Sport.

38 Midori Pulp Storage boxes



36 Ritter Sport paper pouch



37 Carte d'Or paper ice cream tub

- 36 Ritter Sport pouch made with Koehler NexFlex, a paper material with a heat-sealable adhesive that does not impact recyclability and biodegradability
- 37 Carte d'Or ice cream tub made StoraEnso Cupforma Natura 2Bio, a paperboard material with barrier properties that is recyclable and biodegradable
- 38 Midori Pulp Storage stationery made with recycled paper pulp

Beyond recycled paper

Interestingly, paper waste is also useful as a raw material for other materials altogether. The Finnish supplier Infinna Fiber has developed a process that is capable of generating recycled textile fibres from any waste that contains cellulose fibre, such as paper and cardboard waste, as well as discarded cotton textiles. The result is a recycled textile fibre called Infinna that looks and feels similar to cotton. But recycled cellulose fibre is also emerging as an important raw material in the production of other materials, such as a new construction material made with paper waste that can

replace more traditional materials like MDF and drywall by Honext, a start-up based in Barcelona. Another example comes from Richlite, a US-based supplier that makes a paper waste-based sheet material that is also suitable for exterior applications and food contact applications, such as the Nagare collection of tableware by London-based designers 3rd Diadem.

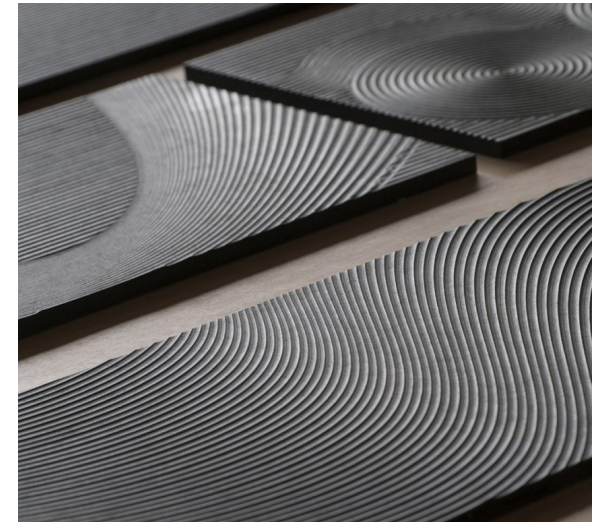
- 39 Wrangler jeans made with Infinna fibre from the Finnish supplier Infinna Fiber
- 40 Honext sheet construction material made with recycled cellulose from paper waste
- 41 Nagare tableware By 3rd Diadem made with Richlite recycled paper-based composite sheet



39 Wrangler jeans



40 Honext



41 Nagare tableware



Nestlé Yes breakfast bar with barrier paper wrapper from Sappi

ONE TO WATCH

Sappi

The South African paper supplier Sappi offers several packaging papers with barrier and sealing properties, making paper a viable alternative to plastic in a wide range of food wrappers, bags and other packaging applications. The ability of these paper materials to be heat-sealed means that they can be used on the same manufacturing lines that are used to make packaging with plastic film materials.

On disposal, the packaging can be recycled with other paper waste, or left to biodegrade in composting, as the barrier- and heat-sealing coatings does not negatively impact the recyclability and biodegradability of the paper.

PAPER RECYCLING

Material degradation

Because paper is shredded as part of the recycling process, the cellulose fibre is shortened with each with each cycle. This means that paper can only be recycled about four times before the degradation of the material becomes too great. At this stage, the material can be composted or used as a biofuel.

De-inking and bleaching

Paper waste can be de-inked and bleached to produce white recycled paper that lacks visible traces of printing inks and other decorative processes. If recycled paper is bleached, ask suppliers to confirm that the process they use is either elemental chlorine free (ECF) or totally chlorine free (TCF).

Certified recycled paper

Both the Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC) offer paper recycling certificates, offering validation that the paper comes from certified recycled sources, and as well as managed forests in the case of paper that is made of a mix of virgin and recycled paper.

Key concepts in paper recycling

Act now

Paper is having something of a revival at the moment, with many new processes and materials being developed that makes paper a very attractive renewable and widely recycled alternative to other, currently less recycled materials, such as petrochemical-based plastics.

- New coatings and adhesives can be used with paper without compromising the recyclability and biodegradability of the material, making paper a viable alternative to plastics in many packaging applications
- Paper waste is a valuable resource that is also increasingly becoming a valuable raw material outside the traditional paper industry. You may be surprised to find the wide range of paper waste-based materials available
- Explore the creative potential of this incredibly rich and tactile material, with a very wide range of creative opportunities in terms of colour, texture and forming

42 Newspaper Wood composite material made with compressed newspaper waste

43 The objects in the U/V Collection by Palefire Studio is made with recycled moulded paper pulp

Newspaper Wood composite material made with compressed newspaper waste

43 Palefire Studio U/V lights



42 Newspaper Wood



TO CONCLUDE

As mentioned in the introduction, this guide is meant to be an introduction to key concepts and processes for recycling some of the most widely used materials in product design today.

Recycling is a fundamentally different approach compared to making materials from virgin raw materials. Managing waste streams through sorting and separation is an inherently messy and complicated business. Knowing more about how these processes work will give designers the skills needed to design products that are easier to take apart for material recovery on disposal.

However, recycling should not be seen as an enabler for the continuation of overconsumption and throwaway culture. Recycling is a fantastic way to keep valuable materials in circulation, potentially indefinitely, but recycling processes still require energy and should be considered the last stop once products have lived out their potential through repairs and reuse.

At the time of writing, new ways of thinking about recycling are being defined. At this point, we don't have good answers for all of the questions and challenges that recycling raises. Our advice is to approach this complex topic with an open mind and treating it as a topic that will continue to evolve and grow over years to come.

Let us know your thoughts on info@chrislefteri.com

44 Metal recycling, like mining, produces slag. Scrap metal and slag piles at a copper recycler used by Studio ThusThat for the This is Copper collection



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