

Splendour in the glass

Jodie Lea Martire continues her investigation of Australia's recycling industries. This time around: glass!

Let's start with words that bring joy to the ears of any environmentalist: glass is 100% recyclable. It can be recycled an infinite number of times without reducing its quality or creating additional waste or by-products. The jar from your strawberry jam, the retro glass bottle of servo Coke, those squat stubbies of ill-advised Sunday night beer... they can all be made and remade into functional glass items, in a process that can continue indefinitely—as long as our recycling system is ready for it.

The oldest-known glass dates back to ancient Egypt's Old Kingdom period (around 2500 BCE). That glass was made from basically the same recipe we follow today for the glass used most commonly in packaging: it's known as "soda-lime" glass, and it includes 70% silica sand (SiO_2), 13% each of soda ash (Na_2CO_3) and limestone (CaCO_3), plus traces of alumina (Al_2O_3) and metal oxides for colouring. In practice, packaging glass uses 25–35% furnace-ready recovered glass scraps called "cullet" (8mm to 50mm); smaller pieces, or "fines" (1mm to 8mm), also have a variety of uses.

Recycling glass, instead of manufacturing new material, provides a whopping 75% energy saving. According to the *National Waste Report 2020*, Australians each generated 46kg of glass waste in 2018–19, or 1.21Mt as a nation; 90% was packaging (mainly bottles). Our recycling rate was 59% and we've accumulated over 20Mt of glass waste in our landfills.

Sweden recycles 93% of its glass, and the European Union has a solid recycling average of 76%. It has also implemented the "Close the Loop" product-stewardship strategy to

bring its rate up to 90% by 2030. Here, the Australian Packaging Covenant Organisation (APCO) aims to make all packaging 100% reusable, recyclable or compostable, while using 50% recycled content, by 2025. So how are we tracking?

How is glass recycled?

Glass containers are tossed by consumers into their recycling. They are taken to a glass recycler or material recycling facility (MRF), where they may be sorted into colours—

amber (brown), green or flint (clear)—if their end-use is new glass vessels. In a process called "beneficiation", glass waste is washed to remove impurities, crushed into cullet and screened to remove hazardous materials and contaminants (plastics, organics, metals, ceramics, gravel). Magnets, air-jets, vacuums, lasers and optical-sorting technologies might also be used in this screening process. The cullet is cleaned, dried, smelted down with raw materials at 1500°C, and air-blown in moulds to make new bottles and jars.

Many commercial suppliers, like pubs, clubs and sporting venues, provide cullet directly. Their on-site glass compactors crush their empties, thus reducing the volume and cost of their waste. Both cullet and fines can be ground and prepared in a range of sizes and textures, to be used as fibreglass, fillers in paint and plastic, water filters, drainage, insulation and sports turf. Other uses include brickmaking, sandblasting, aggregate for concrete, roads and construction, and—ironically enough—as cover for landfills.

Unfortunately, it's very easy to mix up soda-lime glass with other types of glassware, and as non-recyclable glass melts at a different furnace temperature to the recyclable material, its presence can make a whole new batch defective. This is a real problem, because a piece of non-recyclable glass the size of a coin can contaminate an entire tonne of recyclable glass, which will then have to be dumped in landfill.

This means it's worth getting it right when it comes to what you put in your yellow bin. You should definitely put drinks bottles, food jars and flasks of perfume or aftershave in your recycling. Green, amber and clear bottles

Tips for better glass recycling

- Choose refillable/reusable glass bottles, e.g. Barambah Organics milk in Queensland.
- Buy in bulk to reduce the amount of glass packaging you consume.
- Empty and rinse your jars, bottles etc (washing-up water is great).
- Try not to break your glass recycling: it gives your recycler more reuse options.
- Separate containers and lids, and make sure each goes in the appropriate bin.
- Separate out your glass items from your mixed recycling if possible, e.g. in a container-deposit scheme.
- Do some online investigating (and/or check the other boxed text included with this article!) when you need to toss anything other than soda-lime glass.



A comrade in the glass struggle does the right thing.

Image: Fotoeventis/iStockPhoto

are also perfect. However, don't try to recycle any blue, black or white opaque glass. Also, don't be tempted to put in drinking glasses, crockery, earthenware, or cookware like Pyrex or microwave plates. Ditto for eyewear, vases, nail-polish bottles and light bulbs—and definitely no mirrors, device screens, windows, windshields or laboratory glass. Look for the recycling options in your area for these specialist items.

What are the benefits of recycling glass?

Recycling glass can have a big impact on resource use and pollution. Cullet can replace 90% of virgin materials in new green and brown bottles, and 60% in clear bottles. For every tonne of recycled glass, using cullet saves almost 1.2t of mineral resources (665kg of sand, 216.5kg each of soda and limestone, and 75.5kg of feldspar, providing alumina and silica) plus a staggering 15,000L of water. That tonne also reduces water pollution by 50% and air pollution by about 20%.

Including cullet in container glass requires less energy to melt down than raw materials (and incidentally extends furnace life by using lower temperatures). Recycling one glass bottle saves enough energy to power a 20W bulb for 20 hours. For every 10% of

cullet used, energy savings increase by 3% while carbon emissions are reduced by 5%. This equates to 315kg CO₂ saved per recycled tonne of glass.

Recycling glass also avoids problems associated with unused waste stockpiles. Unprocessed glass can hold smelly molasses and alcohol residues, which are high in nitrogen and dangerous to aquatic creatures if they leach into waterways. Contaminants and hazards such as heavy metals, ceramics, flammables and asbestos, if left untreated, can cause health and environmental impacts. You may remember *Four Corners*' 2017 exposé of stockpiled glass waste, in part caused by local industry's inability to compete with cheap container imports (and the odd bit of black-marketeering). In 2020, COAG stated that the container-recycling industry is still "limited", but the Australian Packaging Covenant (APC) estimates that half of Australia's recovered container glass is reissued as new packaging.

Are there drawbacks to recycling glass?

Glass recycling is not without its drawbacks. Even with substantial energy savings, melting 100% glass cullet still uses 1.886GJ (524kWh) of energy per tonne of glass. In addition, glass waste can be hazardous, injuring workers

and damaging machinery. If recovered glass comprises particles larger than 5mm, recycling workers report that the waste is abrasive or sharp. Under 3mm, however, the fines are rounder and less harmful—but less valuable to recycling companies.

In mixed recycling, about 30% of glass is recovered as fines, which are worth less than cullet, and glass slivers become a contaminant in waste paper and cardboard. Broken glass is also difficult to sort and recover: if it's too hard to reclaim, it gets landfilled. Since China's National Sword policy—which banned imports of many recycling materials—was implemented in February 2018, and Australia banned the export of recyclable waste from January 2021, local recyclers have been seeking higher-quality recyclables. Before the ban, Australia exported 25.9kt or 2% of our glass in 2019–20, 89% coming from Victoria and most of it ending up in Malaysia. Now it's up to us to take in our own recycling.

And finally, glass is heavy and needs more fuel to move it along our roads from shops to consumers to recyclers to reprocessors. A 1L glass bottle weighs up to 800g, the plastic equivalent only 40g. High transport costs are one factor that has caused glass manufacturers to reduce the weight of their



containers, but the packaging industry has also seen a shift to plastic at the expense of glass. Major brands like Coles are planning to eliminate glass packaging, and major glass manufacturers have shut furnaces in capital-city plants. This, in turn, results in a shrinking market for both new and recycled glass, and could ultimately leave only "prestige" products in the more expensive containers.

How do we recycle glass in Australia?

Australia's glass recycling system is facing some serious challenges. For starters, 24% of local government areas offer no kerbside glass recycling. Then, in addition to the contamination, loss of market share and furnace closures, the price for mixed recycled glass cullet has bottomed out. In June 2020, it marked a second year of selling for minus \$30 per tonne, where collectors pay recyclers to dispose of it. Green glass from MRFs held steady at \$30 per tonne over the same period, but green glass from container deposit schemes (CDSs)—

which is cleaner and has fewer



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contaminants—dropped from \$100 per tonne to \$75 per tonne. At the same time, glass container re-manufacturers don't always have access to enough high-quality recycled glass to fuel their furnaces, which further hobbles the industry.

Between this situation and China's recycling import ban, the industry seems to be changing its focus from re-manufacture to infrastructure. This has been recognised and/or encouraged in recent government reports, like the *National Waste Report 2020* and the Council of Australian Governments' (COAG) March 2020 strategy in response to the National Sword policy. Artificial sand made from down-cycled glass is now appearing in projects nationwide: footpaths in Albury, asphalt in Melbourne's Tullamarine Freeway, pipe

bedding in the ACT and road grading in Mackay (using glass rescued from its own MRF). Many are only trial projects, but new regulations are being implemented to smooth their use. New South Wales has issued official guidelines for the glass-sand content of asphalt and Victoria launched its Recycled First policy in 2020, requiring all bidders on rail and road projects to maximise recycled materials.

Glass sands offer a range of benefits. Their use reduces the need for sand mining in an industry facing shortages in the medium term, and thus saves the environmental and transport costs of virgin sand. Recycled sands can be pre-graded for different industrial requirements, don't require washing and require less energy for drying and heating. Producing glass sands through councils or MRFs also means low construction miles for local infrastructure projects. (As of 2018, NT and Tasmanian glass was transported to Adelaide or Melbourne.) It also offers a reliable local source of materials that are required in large volumes. There are also Aussie innovations in tile manufacturing and acid-resistant concrete for sewers.

But is this the best use of an infinitely reusable material? Infrastructure projects essentially treat recycled glass like dirt—er, sand—and don't generate the same environmental benefits. Instead, COAG recommends, "Where glass is of high quality, its first order use should be in a glass re-manufacturing process, rather than in infrastructure projects."

How can Australia improve?

In terms of our glass-container recycling rate (59%), Australia doesn't do too badly compared to the global rate of 35%. We beat America on recycling glass packaging (at 31.3%), which is always a relief, but we're nowhere near those

European champions hitting 90%.

One clear difference between Australia and those countries is our limited use of CDSs, but we don't need to go overseas to see the difference they make to the quantity and quality of glass collected. As we saw earlier, CDS glass is priced considerably higher than glass recovered from roadside collections. South Australia's CDS has been running since 1977, and its return rate for glass beverage containers in 2019-20 was 87.8% (though their system doesn't cover wine and spirit bottles). Four new state-based systems have been established since 2017, and the final states (Tasmania and Victoria) will have CDSs operating by 2023. Each scheme operates with varying degrees of manufacturer vs state control (and enthusiasm), but the hope is that CDSs will gain customer recognition and start generating high-volume, high-quality glass for the industry.

Another straightforward fix is separating glass from other kerbside recyclables, which would increase glass quality, simplify sorting and stop it contaminating other co-mingled recycling. All players in the market, from recyclers to glass smelters to government to APCO, agree that this change is vital, not least to rescue the 23% of glass that is recycled kerbside then "lost" in MRFs. Victoria has started rolling out glass-only bins (with purple lids)—it aims to extend these to all households by 2027, a welcome first for Australian states.

The industry, government and APCO each suggests a long list of improvements, not always mutually compatible, for the glass-recycling industry. APCO wants manufacturers to consider product details like colorants, lids and labels, plus increase use of the Australasian Recycling Label to educate consumers. It also encourages light-weighting of glass packaging. CSIRO's Circular Economy Roadmap recommends reusing and refilling glass containers, designing containers without contaminants (to increase recyclability) and increasing their strength to avoid breakage and cross-contamination (even if they weigh more). It also urges glass-only bins in public places, procurement policies which drive recyclable use (including in infrastructure), investment in sorting technologies, and national standards for recycled-glass outputs. COAG recognises the

importance of designing out non-recyclable packaging, increasing domestic demand—both industrial and commercial—for recycled

How to tell if glass can be recycled

As discussed in the main text, including non-recyclable glass in your recycling can have troublesome consequences. Happily, there are ways to tell recyclable soda-lime glass from other types of glass without a laboratory visit:

Crystal

Despite its name, crystal—genuine crystal, anyway—is essentially a more delicate variety of glass, made with different additives: originally lead oxide, now also barium or zinc. Unlike soda-lime glass, it will refract light, creating a prismatic effect when a white light is shone through it. It will also ring melodically when tapped—allegedly, the longer the sound lingers, the higher the lead content.

Borosilicate glass

Borosilicate glass has a low rate of thermal expansion and is thus used in laboratories, but also in items like baking dishes. It's often referred to as "Pyrex", because that company held a patent on the material until 1936. Pyrex products manufactured before that date will be borosilicate glass, while those manufactured afterward may or may not be. Thankfully, there's an easy way to tell the difference. If the glass is Pyrex-branded, look at the case of the word "Pyrex": all upper-case means borosilicate glass, while lower-case means it's most likely tempered soda-lime glass. (The borosilicate version is still manufactured under license in Europe, if you're wondering. The whole subject is a Google rabbit hole that can easily devour an entire afternoon.)

If your item isn't Pyrex branded, the easiest non-destructive way to tell borosilicate glass from soda-lime glass is to immerse it in mineral oil (or, for the technically minded, anything else that shares borosilicate glass's index of refraction, which is 1.474); if the glass is indeed borosilicate, it will seem to "disappear".

Quartz

Technically, all glass contains quartz, because the word refers to silicon dioxide—or, as you may know it, sand—which is the main constituent of all types of glass. However, glass that's only quartz—referred to as fused quartz—is rare, because pure silicon dioxide's melting point, 1670°C, is so high that it's been difficult to generate for most of human history. (This is why people started to experiment with additives in the first place.) If you suspect that what you have on your hands is pure quartz, the best way to tell is to attempt to scratch some glass with it (or vice versa)—pure quartz is harder than soda glass, and will scratch it easily.

Sources: Consumer Affairs, WebstrauntStore.Com, Westlab, Shopify, Gizmodo, Wirecutter

products, and improving regional/national cooperation to meet the needs of remote areas and to streamline requirements and approvals. It also encourages a reassessment of waste levies to boost resource recovery and a specific product-stewardship process for glass items. Glass manufacturers want a single, uniform, national process to reduce market distortion, and a competitive system that supports local innovation and manufacturers.

This laundry list tells us several things. One, that there are many players who are committed to the glass-recycling industry and its success. Two, that each has put considerable thought and research into improvements that would benefit the sector. And three, that there is a lot to be done, much of which can be catalysed by government

policy, legislation, investment and education. Glass recycling needs to be treated as a significant industrial and environmental opportunity, before the system reaches breaking point. 

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RESOURCES:

Recycling Near You

recyclingnearyou.com.au/glass-bottles-jars

Clean Up Australia recycling factsheet:
bit.ly/2QvyPBr

Australasian Recycling Label:
bit.ly/3pVAI80

Case study: Betta Stone

Owner Rob Thompson reckons the idea for Betta Stone "started with the third bottle of wine at a luncheon about 40 years ago", but it took many years of research and industry experience before the first version of their product went out in late 2018. "And it was a failure," he says wryly. Happily, "some days later, with the help of some wonderful chemists and others in our research group, we commenced a product that was all the things we wanted it to be. R&D is forever."

The result of all that R&D is the eponymous Betta Stone, a material that's used to make a range of benchtops and splashbacks for kitchens, restaurants and office spaces. The material is made from recycled glass, "as it comes out of your street bin—from Vegemite to chardonnay".

The company's original aim was to save glass waste from landfill, and "above all, to be Aussie made". Glass is sourced from suppliers in Queensland and Victoria and taken to a warehouse in the Melbourne suburb of Broadmeadows, where it is transformed into slabs that are 85% recycled glass and 15% resins and pigments. Each slab's colour and design depends on the bottles that went into it, and it takes around 800 bottles to provide enough material for an average kitchen.

Regardless of appearance, Betta Stone is lighter and more durable than competitors like marble and granite, less porous than natural stone, and less likely to crack than engineered stone.

So how's it made? This remains something of a mystery: Betta Stone doesn't share production details because it is highly protective of its intellectual property. Thompson explains, "We know how much Australian tech has been lost overseas, and we're quite determined that this is an opportunity for Australia that won't be lost."

He does mention bringing together hydraulic compaction experts, engineers,



Would you believe that this benchtop is recycled glass? Neither did we, to be honest.

Image: Courtesy of Betta Stone

chemists and press designers to make Betta Stone a reality, and the product's safety data says components are "fabricated into solid board using pressure and heat". He also tells *Renew* proudly, "The technique we've developed requires very little energy. [Efficiency] is a prized part of our procedure".

This is clearly a very different process to traditional glass recycling, which requires temperatures between 1427°C and 1538°C, with commensurately sky-high energy costs. Thompson says, "Energy is the lowest cost of the whole production, by far—less than the pigment to achieve the colouring". Eventually Betta Stone will install its own solar setup, as it "aims to be the epitome of the circular economy".

An unexpected benefit of Betta Stone's process is that the end product is 100% free of crystalline silica, which is always present in sand and natural stone, along with concrete, cement and the composite stone used to

make many benchtops. Exposure can cause silicosis, the rate of which has been rising nationwide for the last decade—largely due to the installation of artificial stone benchtops. (Thompson says his company is preparing to establish a trust fund to support victims of silicosis and their families.)

Betta Stone has already been taken up by Woolworths and Arnotts, and the company is in discussion with major high-rise developers and retail outlets. Their "first serious container load enquiry came through" in late April and a factory space has already been secured in Northern Ireland to produce items for sale in Europe. For now, Betta Stone is focused on benchtops, but it has an eye on building cladding, perhaps for 2022. "Hopefully what we do will inspire others," Rob says. "[It's not just] glass! There's any number of other things in your recycling bin that want attention. Landfill is full of opportunities." — *Jodie Lea Martire*