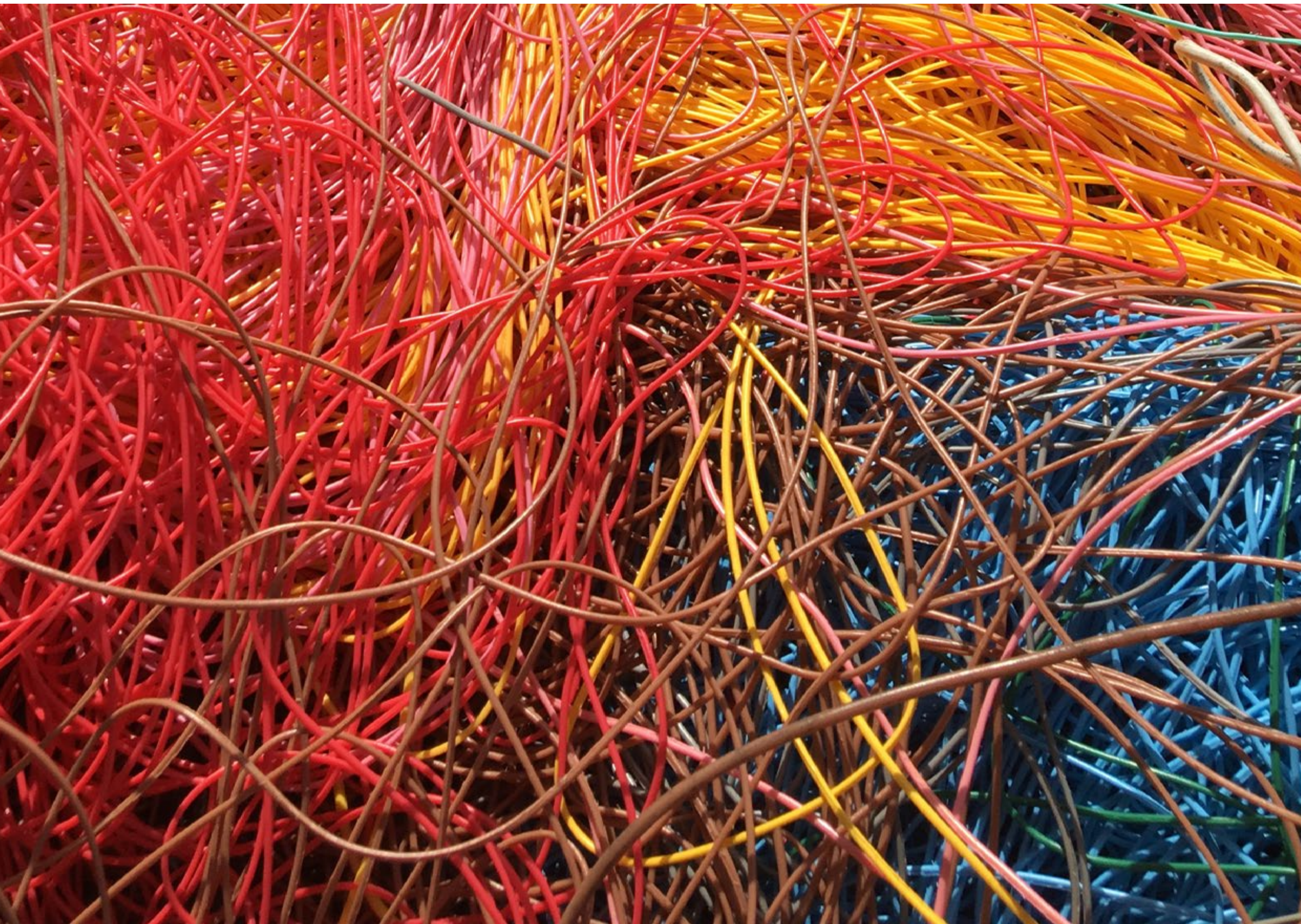
Australia's National Science Agency

PVC recycling in Australia

Current status, barriers, and opportunities

February 2022



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Important disclaimer

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Contents

Introduction

One of Australia's greatest challenges lies in ending plastic waste. In FY 2018–19, only an estimated 11.5% of Australia's plastic consumption was recovered[1]. While it is important to note that percent of consumption is not the best metric for measuring the true recovery rate, particularly for long-lived plastics, it is clear that there is considerable room for improvement. Currently, an estimated 65% of plastics consumed in Australia annually end up in landfill[2].

Through its National Waste Action Plan, Australia has set a national target to achieve 80% resource recovery by 2030 which represents an estimated 1.6 million tonnes of plastic to be recovered by 2030[3]. Achieving this transformation will require not only technical solutions to increase the capacity and capability to recycle plastic but also changes to standards, specifications, collection systems, and beliefs about waste. CSIRO's Ending Plastic Waste Mission is addressing such challenges aiming to increase Australia's circular economy of plastic. The Mission is driving systemic change through data science, materials and manufacturing, recycling processes and whole of life, circular solutions. CSIRO's aim is to achieve an 80 per cent reduction in plastic waste entering the environment by 2030.

The Australian plastics industry is also working on reducing plastic waste through a variety of efforts, including increased recycling. However, there are currently barriers within plastics value chains preventing optimum levels of recycling and manufacturing using recycled, or secondary plastic material.

According to the Australian Plastics Recycling Survey for 2018–19, polyvinyl chloride (PVC) was one of the top four polymers consumed in Australia by weight, but had one of the lowest reported recovery rates[1]. The reasons for this are several. PVC is an extremely durable plastic product with a long life span. In Australia, imported finished products comprise predominately vinyl flooring, but also profiles, cables, and membranes. In contrast, the bulk of virgin PVC resin is used in the manufacture of pipes for water and sewerage infrastructure, plumbing, electrical conduit and irrigation, with a service life typically exceeding 100 years. Due to its long life and below-ground installation, a significant portion of PVC pipe will never be recovered, even at the end of its service life. Instead, it often becomes a host for new pipe, saving energy and resources, and reducing potential environmental impacts from the removal.

These factors make it challenging to gain an accurate measure of the amount of PVC that is available for recycling, and what proportion of that amount is captured and diverted from landfill. It is noted that 'rework' PVC material generated during the course of product manufacturing is reused back into these products in the vast majority of cases, and isn't included in the analysis of recycling rates.

The diverse array of formulations that are used in compounding PVC can present challenges for reprocessers that are interested in using recycled content. Meanwhile, for general plastic recyclers and facilities producing Processes Engineered Fuel (PEF), the chlorine content in PVC makes it a problematic contaminant for other polymer streams.

Here we address the specific case of PVC recycling to better understand the complex, systemic barriers to and opportunities for PVC recycling, and to identify potential future enablers for this industry. This is achieved by mapping the flow of recycled PVC across its value chain, and drawing on interviews with businesses and peak bodies across the PVC industry. With a target audience of state and federal government, industry peak bodies and plastic industry businesses, as well as other interested stakeholders, this study is intended to assist PVC recycling planning and policy, and to support industry best practice. The report is timely, given the Australian government's bans on exporting plastic waste coming into effect in July 2021 and 2022, meaning the imperative to reduce plastic waste in Australia and reduce waste going to landfill is stronger than ever.

1 Envisage Works (2020). 2018-19 Australian Plastics Recycling Survey

2 Schandl H, King S, Walton A, Kaksonen AH, Tapsuwan S and Baynes TM (2020) National circular economy roadmap for plastics, glass, paper and tyres. CSIRO, Australia.

3 National Waste Policy Action Plan, Department of the Environment and Energy, 2019

Research methods

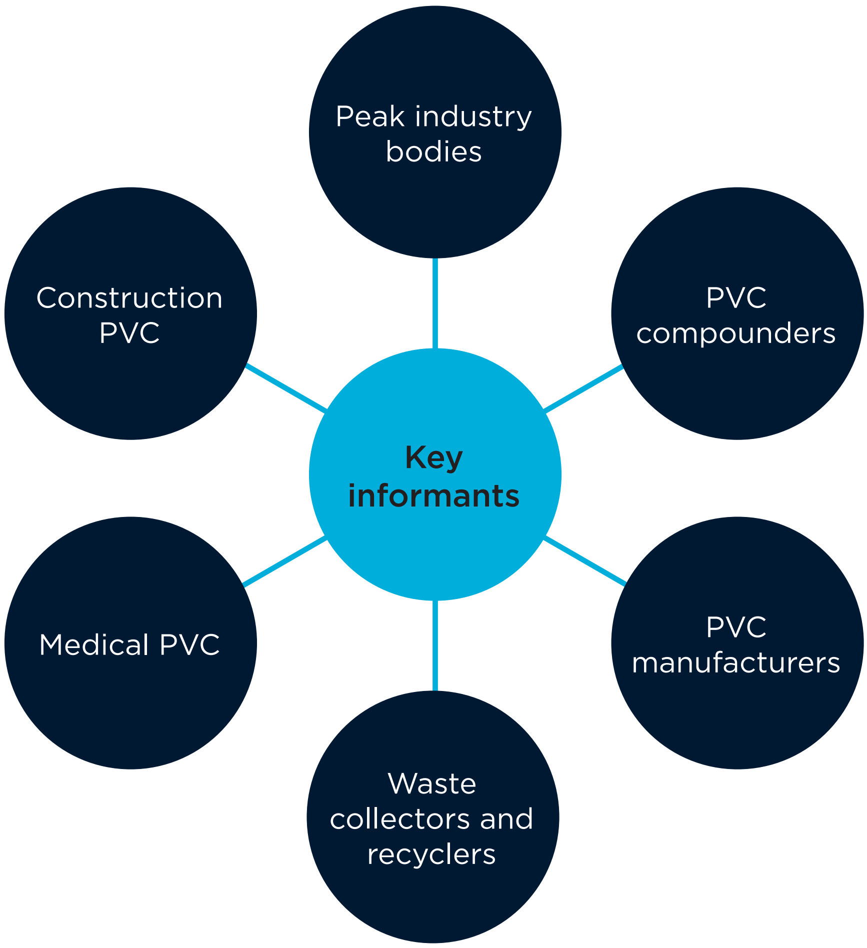
Under the Ending Plastic Waste Mission, CSIRO undertook a small-scale, qualitative pilot scoping study of the PVC value chain in partnership with the National Waste and Recycling Industry Council (NWRIC). The study was conducted using two research instruments:

1. a material flow-diagram
2. semi-structured interviews with key informants in the PVC value chain in Australia.

The material flow-diagram was drafted by the researchers in consultation with NWRIC and the Vinyl Council of Australia.

Interviews were conducted with 15 individuals representing 12 different businesses and industry organisations across 5 states. The interviews were conducted following approval from CSIRO's Human Research Ethics Committee, and adhered to privacy requirements. Participants were identified with assistance from both NWRIC and the Vinyl Council of Australia. The conversations explored barriers and opportunities to PVC recycling, and ground-truthed the material flow-diagram.

The key informant interviews included stakeholders from across the value chain and within different industry sectors, illustrated in the diagram below.

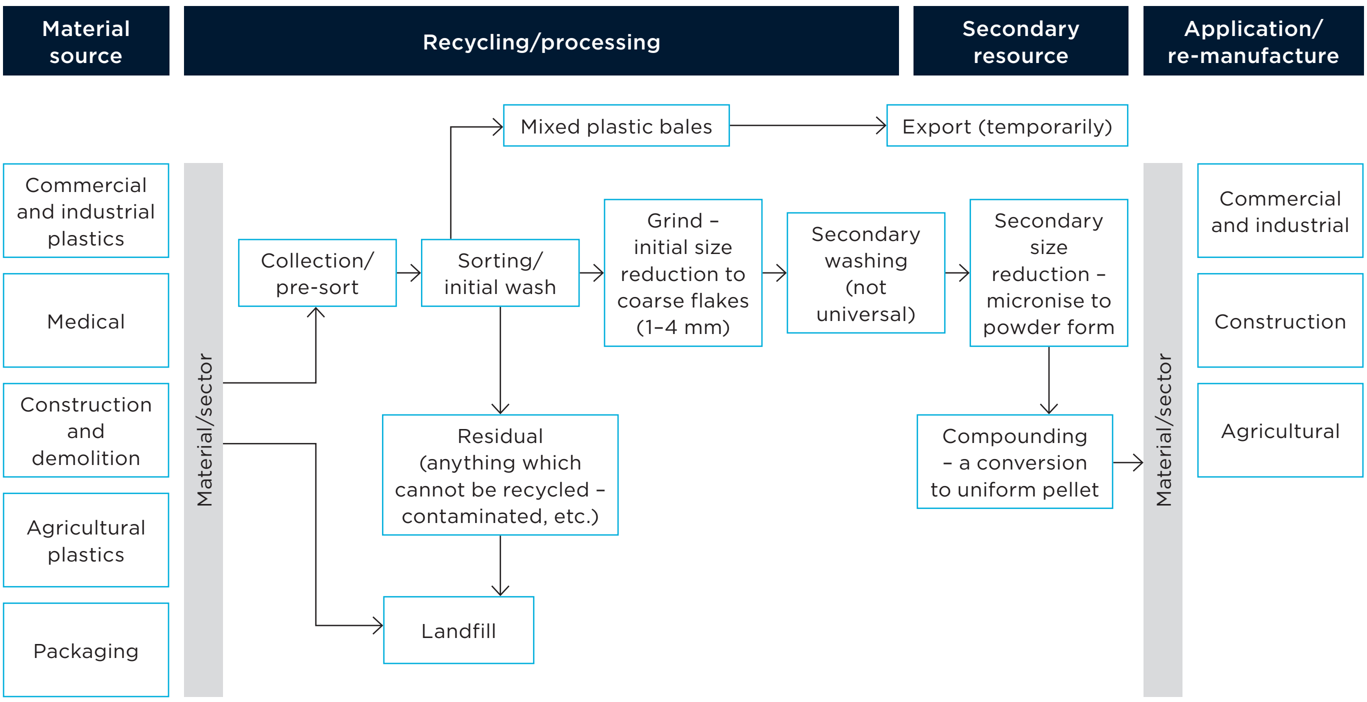


PVC material flow

PVC can be divided into two main types: flexible and rigid. While rigid PVC, or uPVC, can be incorporated into recycled flexible PVC products, the converse is not the case. The added plasticisers in flexible PVC mean that it cannot be readily incorporated into recycled uPVC products. There are several different sectors from which recycled PVC is sourced. Commercial and industrial sources include (among other products) hose, billboard wraps, and auto parts. The medical sector provides primarily IV bags and tubes. There are a range of PVC items used in the C&D industry that are available for recycling, including pipes, conduit, uPVC window and door frames, roof membranes, cladding, vinyl flooring, permanent formwork, etc). PVC is commonly used as plastic sheeting and irrigation in the agricultural sector. Although there are a range of different potential source items, not all are easily incorporated into a recycling stream.

Flexible PVC feedstock currently used for recycling is typically sourced from flexible cables and conduit, IV bags and tubing, and a very limited amount of food grade packaging. VCA is currently conducting a trial of recycling PVC coated textiles (e.g billboard skins and advertising banners). Flexible PVC is, by nature, more flexible, both in respect to its material properties, but also in terms of input sources from recycled material.

In the production of PVC products, industrial processes can result in the generation of in-process scrap that can be collected and ground to produce plastic regrind. This regrind is mixed with virgin material and can be used in the production of certain plastic products, While this is not technically considered recycling, nor is it counted as such within the recycling data, it does reduce waste.



The easiest route for PVC recycling is closed loop recycling. In this scenario, pre-consumer scraps such as trim and offcuts from a specific source (e.g. pipe from a particular manufacturer) is ground and recycled by a recycler or recycler/compounder, and used to create new pipes to the same specifications, by or for the same manufacturer. This is the easiest way for recycler/compounders to recycle PVC waste, as the feedstock is generally free from contamination, and the proportions of additives (fillers, stabilisers), are already known.

Recycling post-consumer waste such as offcuts from building sites (formwork or pipes) is also quite feasible, but contamination rates tend to be higher. These items can be granulated by a third party and sold to other manufacturers, or used by the original product supplier.

Recycling post-consumer waste at end-of-life typically has significantly more contamination. This is especially challenging when dealing with mixed sources of PVC, as there are a large variety of formulations used when compounding PVC.

There are a variety of applications that currently use recycled PVC. The commercial/industrial sector makes hoses, boots, among other items. Pipes, electrical conduit, decking, fences, vinyl flooring, and custom extrusion profiles are among those products produced for the construction industry. Recycled PVC is sometimes used for low-pressure irrigation pipes.

Case study 1: Medical

In partnership with the VCA, medical giant Baxter has initiated an extended producer responsibility scheme to encourage the recycling of its single-use, intravenous bags. Manufactured from flexible PVC, the bags must be produced from virgin resin, not recycled material, to meet the health industry's stringent standards. Baxter finances and organises the collection of the bags for recycling, following use in hospitals and homes, helping hospitals to achieve their sustainability targets. Some of the barriers that Baxter has had to overcome include the need for limited on-site pre-processing (separation of non-PVC labels, clips, etc), as well as transport logistics. Training for hospital personnel in pre-processing has been critical. A PVC compounder/recycler, Welvic, receives and processes the used material, selling onto others to produce goods such as hoses and gumboots in Australia.

Case study 2: Construction

PVC is commonly used in the construction industry, in pipes, conduit, electrical wires, door and window frames, and permanent form work. During the process of a new build, particularly in larger sites, there can be significant waste from PVC offcuts. Rainbow Plastics, a recycler based in WA, has begun placing bins for HDPE and PVC on construction sites, to add to the pre-existing bins for other scrap materials. These collection facilities can be profitable for both the recycler as well as the construction company, as they can significantly reduce landfill gate fees. However, contamination of these bins is a common problem for many waste streams. To address this problem, Rainbow Plastics have not only educated the construction companies, but are also trialling charging a fee for collection that is refundable if the load is of high enough quality. This scheme could accommodate several different grades, representing different levels of contamination.

Key challenges for PVC recycling

Australia's PVC recycling industry has particular characteristics, such as remote collection, small volumes and multiple jurisdictions, that add challenge and complexity. The interviews identified nine key challenges that are currently impeding the extent of recycling PVC.

Insufficient supply of input material can be a challenge for those using recycled PVC. Due to the long service life of many products, coupled with a shrinking local manufacturing sector, there are limits to the types and volumes of material available as sources for PVC recycling. Small volumes of source material make it difficult to develop cost-effective solutions and extend market opportunities for manufacturing new products. The development of new reprocessors is certainly limited by small volumes. The lack of adequate supply has almost certainly led to the cessation of schemes to recycle the small volumes of flexible plastic PVC recycling from municipal sources.

Achieving a clean source of post-consumer waste is challenging: Some available sources (eg. demolition waste) are highly contaminated, which prevents recycling of some otherwise recyclable material. There are also challenges associated with legacy additives such as lead, which used to be used as a stabiliser in rigid PVC, though there are certain products (e.g. pipe) that can safely incorporate these legacy additives. Collecting post-consumer PVC separated at source requires specific collection processes and consumer behaviours to ensure an effective and contaminant-free supply. For example, flexible PVC used in the medical sector has a dedicated system for collection in many hospitals, and rigid PVC is now commonly separated at some large construction sites. These processes require additional time and staff training, as well as a dedicated bin or facility to store the waste before it is collected. The costs borne by the user may be offset by the reduction in cost of sending the PVC waste to landfill, providing a modest incentive for recycling the PVC waste. As a result of the difficulties associated with collection and sourcing a clean supply of secondary PVC, compounders often establish closed loop collection arrangements with PVC manufacturers who send them the 'offcuts' from their manufacturing processes.

The **logistics** of collecting waste PVC for recycling are not straightforward. In many cases, small and volatile volumes of source material make storage, transport, and recycling economically unviable. In remote locations it can simply be too expensive to source across multiple, geographically dispersed locations the small volumes available, particularly when processors are located across state boundaries. As a result, different regions of Australia are more effectively able to recycle PVC than other locations. For example, in Victoria, travel distances are relatively low, and the number of compounders and manufacturers is relatively high, so it is easier to recycle PVC there than in other parts of Australia. In contrast, the long distances and dispersed locations of urban areas along the Queensland coastline limits the opportunities for PVC recycling in that state. Remote mining sites use small quantities of PVC material (along with much larger volumes of PE), and are another example of waste generators where the cost of logistics reduces the options for recycling.

Another issue with transporting PVC waste is that rigid PVC tends to be high volume but low weight, further adding to the cost inefficiency of transporting post-consumer PVC. Recycler/compounders discourage the practice of shredding prior to transport, as there is little opportunity to control the content and potential contamination of the feedstock.

The **ease of use** of recycled material can also depend on the types of products being made, both in their design and in some specifications for output goods. Manufacturing using virgin resin is less technically challenging than operating extruders using recycled feedstocks. For companies wanting to use recycled material, there are limitations in the types of products that can be made with recycled PVC in general, and further limitations depending on the specific feedstocks that are available for use. For those companies recycling PVC, there may be limitations in financing or housing specialised equipment for testing or size reduction equipment.

Perceptions of recycling as a cheap way to get rid of 'rubbish' can prevent improvements being made across the value chain, for example in collection and reduction of contamination. Where PVC can be sent to landfill more cheaply than being used by a recycler, there is less incentive for diversion from landfill.

Perceptions of inferior products can also limit the growth of markets in recycled PVC goods. There is a prevailing perception among manufacturers that recycled PVC cannot meet the same standards as virgin PVC. Additionally, colour options for recycled PVC are limited when compared to using virgin material. Unless the source is separated by colour (potentially incurring additional expense), recycled PVC tends to be grey or black. While this issue is inconsequential in some applications, it does restrict the use of recycled product in some cases. This leads to a belief that recycled PVC should be cheaper than virgin PVC. The expectations and perceptions of recycled products by end users can also influence market demand.

The above challenges can lead to difficulty for recyclers in **finding appropriate markets.** Some recyclers had enough supply of PVC feedstock, but did not experience enough demand for their material. This could be influenced by the premiums imposed by Australian processing costs, as opposed to the availability of cheaper virgin materials produced overseas.

Structural barriers such as the availability of finance and insurance, and differences in standards both internationally as well as regionally or locally are preventing some opportunities for recycling businesses to expand.

For example, in some areas, neighbouring jurisdictions may differ on what types of pipe they are willing to approve. Some may even prohibit the use of recycled material, even if the specifications of the material are adequate for the intended purpose.

In certain circumstances, products that are produced overseas are subject to extended producer responsibility schemes, where the manufacturers would pay to have them returned at end-of-life. However, due to Australia's waste export ban, it is logistically demanding to ship these items internationally. Shippers have to apply for permits, and the regulations discourage shipping of waste which hasn't undergone some level of reprocessing. In other circumstances, manufacturers that are a subsidiary of an international company would like to be able to use recycled product, and would be able to use it according to Australian standards and regulations, but are prohibited by the parent company's requirements and specifications.

The lack of **reliable data** on feedstock availability, and accurate estimates of recycling rates can also hamper innovation and expansion within the industry. This is especially challenging in the case of PVC, as data on recovery tends to be reported as the proportion of the total consumption of a particular polymer. This figure might be accurate for single use or short-lived items, but certainly under-represents recovery rates for more durable items.

Key opportunities for PVC recycling

There are a range of products that are currently being produced in Australia from recycled PVC. These include footwear, flooring, hosing, pipes, and construction and electrical products, some of which are more expensive than their counterparts made from virgin materials overseas. For some producers, the opportunity to reduce their environmental footprint is a desirable goal in itself but can also be used to differentiate the product from competitors.

Industry associations such as The Plastics Industry Pipe Association (PIPA) play a role in educating key stakeholders who work with plastic pipes, such as plumbers, to better understand their role in responsible disposal. This work has demonstrated the importance of education on the recyclability of PVC, and informs the development of improved collection methods. Education can transform the perception of input material from 'scrap' to 'commodity'.

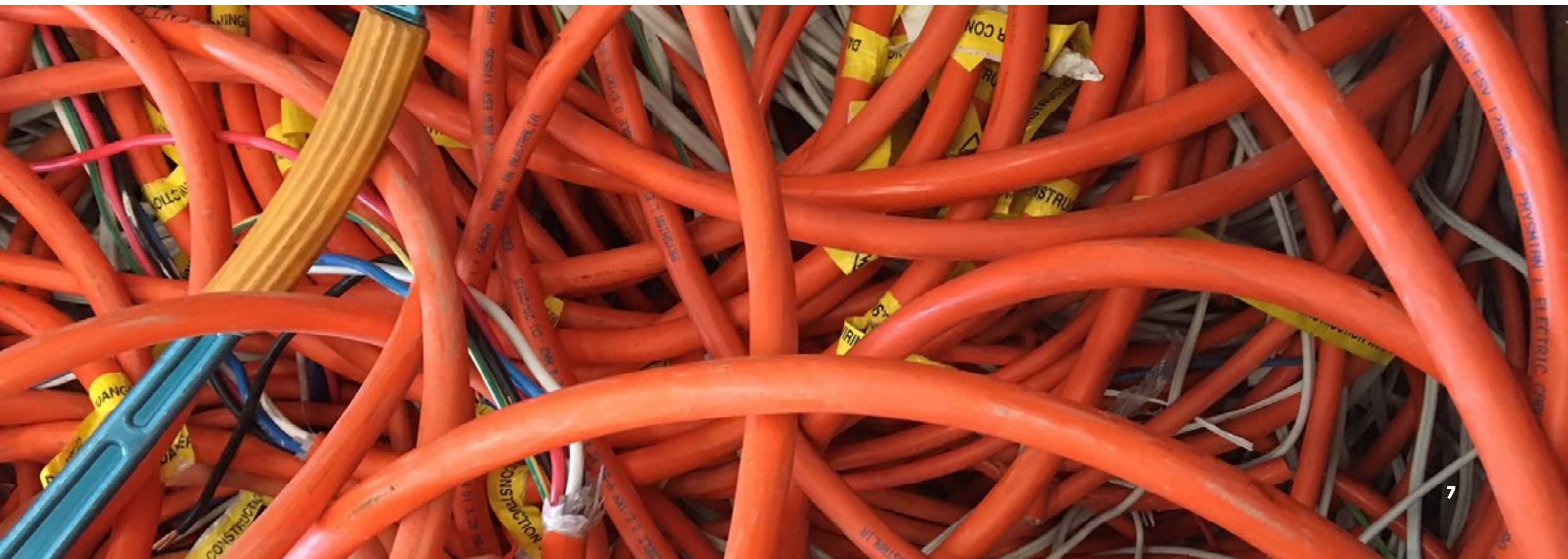
Despite the active PVC market, there is still a significant amount of PVC that ends up in landfill, particularly from post-consumer waste, that could potentially be separated, dependent on cost. There is a growing policy environment around the country to improve material and product recovery, and divert waste from landfill, which has the potential to increase the volumes of recyclable PVC feedstocks. Additionally, there are potentially large volumes of feedstock available in the C&D industry (mainly flexible PVC), and smaller volumes in the mining industry, if the challenges of contamination and distance can be overcome.

The growing market in uPVC window frames also represents a potential source of recycled uPVC, starting in the short term with fabrication offcuts, and gradually increasing as products reach end-of life. Additionally, brand owners and end users are increasingly seeking recycling solutions for PVC products at end of life, so the opportunities for collaboration along the value chain continue to improve.

As Australia invests in enhancing the circularity of our economy, including implementing environmentally friendly procurement policies, additional EPR schemes and market pull could help to make PVC recycling a more financially attractive proposition for many companies. Already, companies are taking advantage of funding opportunities to enhance their capacity to recycle.

VCA has recently commissioned an update of a Material Flows Analysis to provide estimates of waste generation by key PVC applications. Being able to validate the data on a regular basis would enhance market confidence.

Many of these opportunities are driven by an increase in social will and public interest in the plastic crisis, and consumers are demanding new and innovative solutions to the waste problem.



Future enablers of PVC recycling

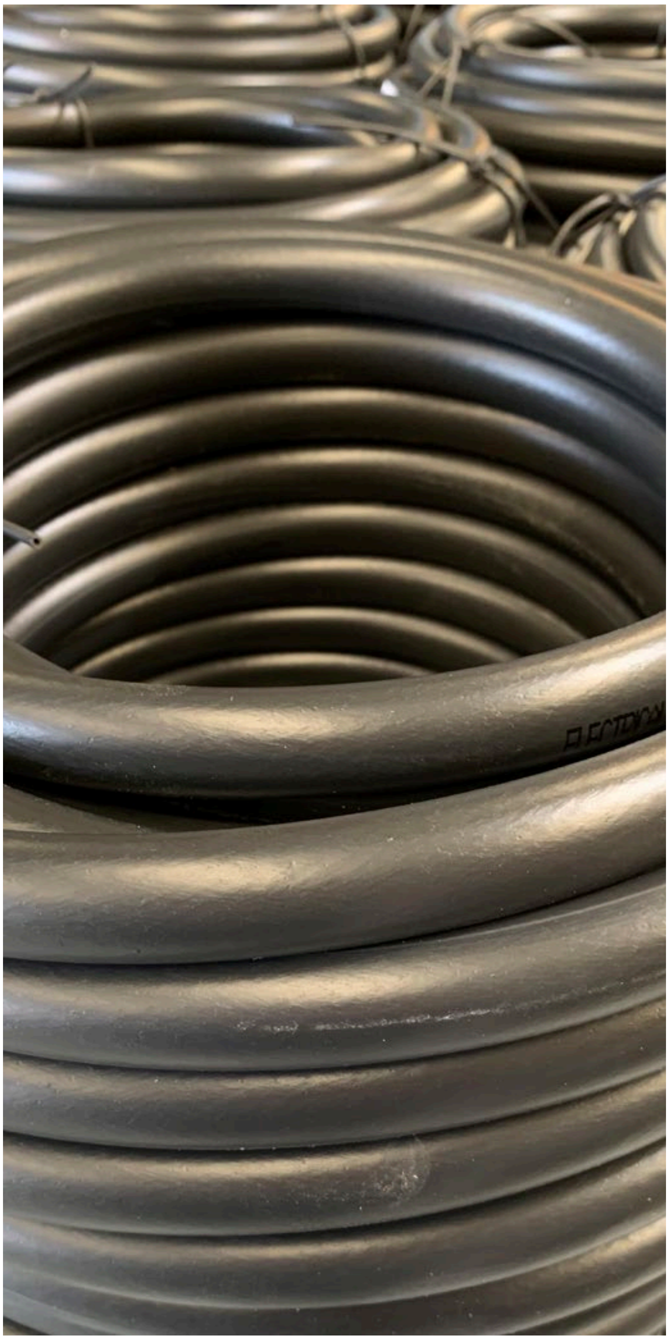
Given the above-discussed barriers to and opportunities for PVC recycling, what will enable the PVC value chain to move towards greater use of plastic waste? Rather than any one silver bullet, a range of enablers is likely to catalyse growth in the PVC recycling industry.

Role of specifications and standards in PVC recycling

The question of introducing standards or specifications at different points elicited an array of responses among stakeholders. On one hand, the small volumes, mixed sources and niche products that characterise the Australian recycled PVC market may mean that the introduction of specifications is not enough on its own to catalyse expansion of the market. Some respondents believed that introducing specifications could have the effect of reducing supply, as suppliers may simply take their material elsewhere if the specifications are too onerous.

On the other hand, firms that develop the technical expertise and capabilities, such as flexibility to deal with changing sources of material, are catalysing market change. Standardisation across the PVC value chain from manufacturer to collected product could shift the perception of recyclable material from ‘scrap’ to ‘commodity’. Material specifications could help with identification of the content of pre-ground input material, because there is a market need for greater assurance of purity of content. Application-specific specifications should be developed in order to encourage implementation of sorting practices that maximise the value of the recovered material.

Apart from material specifications, it is critical to address the problems that arise from inadequate harmonisation of specifications across municipalities, as well as the unintended consequences of regulations that inadvertently discourage the use of recycled products or materials.



Policy/regulation

In some contexts, policy plays an important role in increasing the demand for recycled items, and ensuring recycled content in manufacturing. For example, the European plastic packaging directive requires 30% recycled content in plastic bottles by 2030[4], and additionally sets mandatory targets for recovery and recycling of packaging waste.

In Australia, the Australian Packaging Covenant has established voluntary guidelines for recycled content and recyclability of packaging, which were also adopted by the federal government in its National Plastic Plan. However, these are currently only voluntary targets. Passing a similar regulation for plastic goods in Australia could improve recycled PVC content in some products for which recycled content would meet specifications, but only if there was an adequate supply of feedstock. Given the constraints within the market, mandatory targets may be difficult to achieve currently, though this legislation would certainly help to drive market demand for recycled feedstocks.

An alternate option would be to implement (or increase) landfill levies, or to ban landfill of certain items. This incentivises waste disposers to create and demand opportunities for circularity.

Government regulation or incentives helping to foster circularity in the plastics market, as well as extended producer responsibility, would work on the problem from the perspective of the manufacturer, and would have a similar effect of boosting both supply and demand. While this report does not address the mechanisms by which the circular economy is to be achieved, regulations could include requirements for products to be recyclable, establishing a tax on items (both foreign and domestic) that do not achieve recyclability, or requiring EPR schemes for particularly problematic materials.

Research and development

One of the barriers to recycling is the expense of sorting PVC from other polymers. Enhanced separation technology is successfully being used in Europe to identify and separate PVC from mixed waste. However, this technology is expensive, and given small volumes of PVC in Australian markets, may not be a cost-effective solution. Modifications to this technology could enable use in an Australian context, or perhaps in conjunction with regional recycling hubs.

Another barrier to recycling of PVC is mixed feedstocks. Without an adequate understanding of the precise chemical formulation of the feedstock, recycling is challenging indeed. Developing a tool to analyse this chemical formulation would help to improve trust of shredded product, in turn adding logistical feasibility to transporting feedstock, and potentially broadening the range of products that could be made with recycled plastics.

Enhancing data collection systems would be extremely useful in both encouraging the growth of the recycling market, but also being able to track the effectiveness of programs and interventions aimed at increasing recycling rates. Currently, the National Plastics Recycling Survey is conducted annually, and relies on voluntary responses by companies. Measures aimed at increasing the response rate, such as mandatory reporting, or reporting as a requirement for accreditation would help to enhance confidence in and accuracy of these estimates.

New/existing feedstocks

With the volumes of potential feedstocks currently available, it is critical to develop ways to access these in a cost-effective manner. Regional recycling hubs and mobile shredders have been proposed as potential enablers that might assist, especially in states with long distances between source locations and recycling facilities.

4 European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste

Conclusion

Despite the challenges inherent in PVC recycling, there are significant opportunities within the industry. The peak industry body, the Vinyl Council of Australia, has initiated a number of programs aimed at recovering and recycling single sources of PVC such as medical waste and PVC coated textiles. Innovative companies are investigating how to access the vast quantities of material in remote areas and in sectors such as C&D and mining. However, it is critical to ensure both an adequate supply of recyclable feedstock, as well as a market demand for recycled products. There are roles for both industry and government to play here. Government procurement policies that encourage use of recycled materials over virgin ones, funding R&D and recycling hubs, and investigating the utility of standards and policies could all assist in driving market forces. Industry-led adoption of material specifications could also help to redefine recycled PVC as a commodity, mitigate disposal costs, and drive investor confidence. And, critically, systems for data collection will help the industry as a whole to understand the scope of both the problems, as well as the solutions.

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