

REMAKE

Advertising Billboard Skins
Recycling Project 2015 - 2017



Introduction

The Vinyl Council of Australia has successfully completed a project funded with a \$68,833 grant from the NSW Environment Trust for research and development of solutions to complex 'wastes', namely advertising billboard skins. Together with industry, this grant enabled an investment of over \$300,000 into PVC recycling in Australia.

Industry estimates that around 1.2 million m² (500 tonnes) of vinyl (PVC) coated fabrics used as advertising billboard skins are disposed to landfill each year in Australia. Similar fabrics are used in other applications such as truck tarpaulins and wheat grain covers. While these latter products have a longer life of 5-10 years, each year an estimated 5,000 tonnes ends up in Australian landfill.

As an organisation committed to encouraging product stewardship, the Vinyl Council decided to coordinate a project under its PVC Stewardship Program to stimulate changes for this material in Australia. The starting point was advertising banners because these branded products are carefully stored in warehouses at end of life and therefore collection and sourcing from this sector is relatively easy.



To develop the project and submission to the NSW Environment Trust the Vinyl Council pulled together a multi-disciplinary team from manufacturing, distributors, industrial design, end users and material science.

The purpose of the ambitious project was to break through two persistent recycling problems:

1. Advertising billboard skins, and other PVC coated polyester fabric, are difficult to recycle because they comprise two different melded polymers. The project explored whether it would be feasible to reprocess the material as a composite where the polyester fibres could be a beneficial part of the recycled material, or whether the PVC and polyester had to be separated to optimise results;
2. There was no evident local market for the re-processed materials. Unlike other products like paper, cardboard, metal or plastic milk bottles, there have been no well-established reprocessing or non-landfill destinations for vinyl coated fabric. Low volumes of billboard skins have been repurposed as bags or building membranes but these applications would be unable to absorb the quantities of end-of-use material available. It was

essential to find local manufacturers and product applications that would use large volumes.

As noted in the Vinyl Council's 2015-2018 Recycling Strategy 'there is no recycling if there is no end market'.

The Vinyl Council had some confidence that it was on the right path. In 2014, the Vinyl Council and its member, Rojo Pacific, commenced a collaborative project with Monash University funded by a small grant from the Victorian Government Department of Industry. Four senior students (Chemical Engineering and Industrial Design disciplines) were engaged part time for 12 weeks to explore both the reprocessing and end market challenges. The students collaborated with PVC manufacturers to identify potential solutions. The positive, innovative results were presented at forums and exhibitions.

Buoyed by the results, the Vinyl Council applied in 2015 for further funds from the NSW Environment Trust to take this work to the next level. The funds were approved in early 2016 through NSW's 'Problematic Wastes' program, funded through the Waste Less Recycle More program, itself funded by the NSW landfill levy.

The facts and the nature of the 'problem'

Vinyl coated fabrics are used for advertising billboard skins because the material has good durability, weatherability and flexibility and is excellent for print.

In Australia, landfill has been the major waste disposal route and is relatively cheap. There were few examples from around the world of these applications being recycled. In Europe, an innovative solvent-based process called Vinyloop is being used to recycle PVC coated fabrics in a scheme called Taxyloop. The Vinyl Council and members investigated this option for Australia. However, it was apparent that the required investment of approximately A\$15 million to licence and build this technology was an impossibly expensive investment given the scale of the Australian market. Other technologies identified in Germany and Japan were informative but not readily adaptable to this market. Therefore, innovative, lower cost reprocessing solutions were required for Australia.

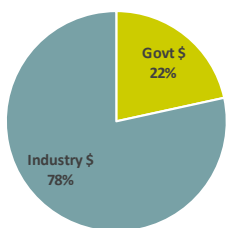
A key challenge is that traditional mechanical separation techniques tend to leave residual cross contamination of the two polymers reducing the usability of the polyester and PVC recyclates. The process also involves granulating the material which results in very short polyester fibre lengths, further reducing the reusability of the polyester.

Outdoor media companies indicated that the direct cost to the advertising and printing industry in NSW alone in sending billboard skins to landfill is around \$200,000 per year. Companies estimated this represents \$10,000 per

month per printer and installer in NSW, which has to be covered by customers or profit margins. A few companies divert a small proportion of skins offshore to give the material an extended life as covers for emergency shelters, however, the majority pay to send the material to landfill.

Roles and responsibilities

Team participant	Project relevance	Project Roles
Vinyl Council of Australia and its members:	Industry stewardship	Project coordination, promotions, linking industry with universities
Rojo Pacific	Product distributor	Supplier of coated fabric
Welvic Australia	PVC compound-er/recycler	Coordinator for different methods of reprocessing with own equipment and others in industry
Paper Freight	Recycling technology	Testing own innovative technology on separating PVC and polyester
PMG Engineering Monash Art Design & Architecture (MADA)	Injection moulder Doctorates, Research Assistants and students in Industrial Design	Making moulds, testing material, trials Innovative design concepts and prototypes, coordinating workshop with students and industry, displays at industry events.
University of New South Wales	Doctorate & Research Assistant, Centre for Sustainable Materials Research & Technology	Laboratory testing of combinations of material to characterise chemical and mechanical properties
Outdoor Media Association	Industry association for product users/ consumers of Advertising billboard skins	Coordinate members' forum, share insights and promote to industry.



The budget for the project, including in-kind contributions was approximately \$319,000 with \$68,833 from the NSW Environment Trust.

Project methodology

The project commenced in February 2016 with the appointment of researchers at both Universities and the first of several industry magazine articles. Teleconferences were held regularly to facilitate exchange of ideas, innovation and collaboration amongst the team. Samples of material were transported, granulated and dispatched to multiple sites for testing, trials, new processes and potential products. The project succeeded because of the positive spirit of collaboration and innovation.

Key stages to the project

Project stage	Participant	Outcomes
Characterisation of reprocessed material	University of NSW	Detailed laboratory tests conducted and reported to industry (see below).
Reprocessing tests & exploration	Welvic Australia	Several tests in-house to mechanically separate the PVC from the polyester and also to reprocess without separation.
	Paper Freight Australia	Developed and tested innovative technology to separate vinyl from poly-ester fabric. Lodged patent.
Tests to explore use of recycle	Close the Loop	Tests concluded recycle was unsuitable for mixing with bitumen for asphalt – this path of enquiry was discontinued.
	PMG Engineering	Tested material for injection moulding of potential products.
Design work developing product ideas, concepts and prototypes	PMG Engineering	Identified potential products for an existing customer for the material.
	Monash University (MADA)	Primary role to develop product concepts and prototypes to absorb recycle. Held Design Workshop with over 50 contributors including students and industry investigating reprocessing techniques including cutting, blending, stripping the material, 3D printing, rotomolding; and product ideas. Further events and a Student Exhibition refined and developed designs. Concept designs selected to proceed to prototypes.
	Boral Masonry	Proposed a product to be made to meet their specification requirements.
	Outdoor Media Assoc, Rojo Pacific and Vinyl Council Australia	Teleconference call meetings and a Forum in Sydney discussed challenges, material pathways, collection, costs, benefits and potential industry program.
Recycling Feasibility	Vinyl Council, MADA and UNSW	Final reports on each key component and case studies.
Sharing Results	Vinyl Council and MADA	Local and international conference presentations. Display of prototypes at Waste Expo, Melbourne October 2017.

Outcomes

The collaborative approach in pursuing innovative recycling solutions for recycling billboard skins led to valuable, highly experimental and investment-worthy results. Monash University and Vinyl Council member manufacturers developed several processing and product ideas:

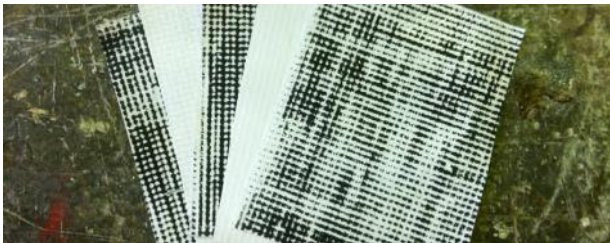
- 1) **Reprocessing the material as a composite** (i.e. not separating the polyester from the PVC).

Cut and welded banner for skateboards and bags.

Shannon Kok, Industrial Design/Mech Eng, Monash Uni



Ink removal and heat welding of sheets, Monash Uni



- 2) **Mechanically separated PVC** (shredded, granulated and spun) to achieve PVC with < 3% polyester for:

- injection moulding;
- producing 3D printing filament;
- roto-molding into shapes.



Project poster 3D printed filament. Sarah Cielech, Industrial Design, Monash Uni

- 3) **Chemical separation technology** developed by Vinyl Council member, Paper Freight in Ballarat, Victoria to separate PVC and polyester through a mechanical and catalyst-initiated process. It reduced the cross contamination of recyclate streams significantly and

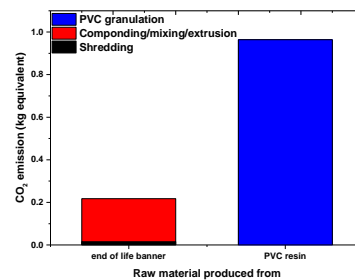
allows for end users of polyester recyclate to determine the preferred fibre length for recycling. The technology, PVC Separation, has since been internationally patented and customers for the recyclate streams are being identified. The cost of developing a plant is estimated at Aus\$1.5-2.0 million.

Separated PVC and polyester, Paper Freight.



- 4) **Chemical engineering research** by the University of NSW's Centre for Sustainable Materials Research and Technology analysed and characterised the recyclates to understand the physical properties that may suit new products. Key findings by UNSW were:

- End-of-life billboard material is stable up to 200°C with no evolution of toxic gases. A major element/constituent is calcium carbonate.
- The addition of cable scrap to billboard material made it denser. Different combination percentages were all tested for flexural and tensile strength. 100% billboard material showed a tensile strength of 6.4MPa.
- All of the mixed samples were capable of withstanding challenges of different working conditions such as chemical attack. Independent laboratory leachate tests proved the reprocessed plastics have potential in both indoor and outdoor applications.
- E-ray diffraction proved no evidence of structural change in banner material even after 5 heating cycles.
- Recycled banner material shows higher flexural strength and modulus than recycled cable material.
- Life cycle analysis estimated the CO₂ emissions for the process to produce PVC recyclate from end-of-life billboard skins were 77.4% less compared to producing virgin PVC granules.



*Graph of life cycle CO₂ emissions arising from billboard recyclate vs virgin resin
UNSW*

- 5) **A number of product concepts and prototypes** were developed by Monash University and Vinyl Council member manufacturers during this project and assessed for feasibility (see table over page).

	Manufacturability	Need	Cultural appropriateness	Visibility	Material quantity	Production opportunities	Relevant exemplar	Ease of application	Timeliness	Cost
Architectural Shingle/Roof Tile	X	X	X	X	X	o	X	X	X	X
Boral Slider Sheet	X	X	X		o	X	X	X	X	X
Deep Root Watering System	X		X	X		o	X		X	
Melbourne Farmer's Market Bag	X		X			o	o	X	X	X

Assessing four refined outcomes against project criteria (X = high confidence, o = marginal confidence)., Design Report, Monash University, Department of Design, October 2017

The following product concepts were explored further.

- **A safety flooring mat** made from injection-moulded recycled billboard skins and cable scrap, which a local manufacturer plans to scale up to full production.



Composite safety mat, Welvic Aust and PMG Engineering

- **A pallet slider sheet** made from scraped and welded banner material designed to meet potential customer's specifications



Slider sheet, Monash University to Boral's specifications

- **Roof shingles** made from cut and compression-welded banner material ready for consideration by a manufacturer.



Roof shingles, Monash University and Welvic Australia

Other quality and volume product concept designs developed by the Monash University students may be

worthy of further exploration and development for manufacture in Australia from recovered materials. Detailed reports from both Monash and UNSW are available from the Vinyl Council.

Lessons from the project

These outcomes are the result of persistent innovation, collaboration and a vision to achieve a circular economy. We used a participatory process to engage and pursue opportunities for a circular economy, including peer to peer exchange, and a very successful, participatory Design Lab event conducted by MADA's industrial design team. We collaborated widely with a large variety of stakeholders across several industry sectors.

Nevertheless, we are still some way from a long term, market-based, viable solution. The next steps will be:

- To further refine the reprocessing technologies
- To continue a feasibility study with Boral to test the two final design outcomes for manufacturability and fitness for purpose
- To identify other customers and manufacturers for the potential end uses of these materials
- To engage with the industry that supplies and uses billboard skins to develop the business case for an industry-wide collection and recycling, or stewardship scheme, and the market push for the products
- To encourage leaders in outdoor media and brand owners to contribute financially to the next stage of the program.

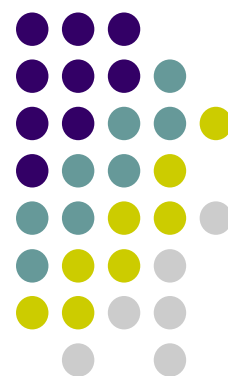
Other key lessons are that:

1. Australia has the expertise to develop innovative solutions - collaboration and financial investment are key
2. Both reprocessing technology solutions and end-market outlets for recycle must be developed hand-in-hand
3. The cost of landfill in Australia, the small scale of our markets and the price of virgin materials make recycling economically challenging.

Conclusion

This project has valuably continued industry's progress in finding a solution to the recycling of PVC coated fabrics in Australia. Further encouragement of circular economy programs would lift recycling rates, support reprocessing of complex products as well as generate jobs and innovation, leading to a step change in diverting difficult but quality products from landfill.

The Vinyl Council congratulates and appreciates the contribution of all those involved, and looks forward to continued pursuit of the goal of a more sustainable and productive circular economy in Australia.



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