Waste-to-Value : Textiles as Raw Materials for Other Industries

Case studies : two types of textile composition product pathway pilot projects

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Purpose of this document

The Formary / UsedFULLY are undertaking a Ministry for the Environment Waste Minimisation Fund funded "Textile Product Stewardship Project" (TPSP), as defined by Deed Number 23433. This report summarises the two Waste-to-Value Product Pathways Pilot Projects initiated as part of this project.

Acknowledgements

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Disclaimer

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Ministry for the Environment
Manatū Mō Te Taiao

Waste Minimisation Fund

Background

The growth in manufactured textile volume is resulting in increasing volumes of textiles being sent to landfill at end-of-use with the knock-on increase of biogenic methane emissions from decaying textiles. While the rate of emissions varies by geography (and level of research), there is alignment on the fact that after food waste, textiles are a hotspot for emissions in landfill.

The export of our unwanted clothing has a number of negative consequences – it undercuts local clothing production resulting in the loss of skilled jobs, and it replaces localised clothing with used western clothing, with the loss of local interpretation and cultural expression through clothing design. Off-shoring used garments also pushes the associated environmental and social impacts to other countries. It does not address the volume of textiles we are consuming and also does not meet consumer expectations of resource reuse and environmental stewardship.

Lack of onshore textile manufacturing has necessitated viewing textile resources not from a product level i.e. textiles, but from a resource level. Textiles are broadly cellulosic – cotton, linen, protein – wool, silk, or petrochemical based – polyester, nylon, acrylic. The only existing textile processing capability in Aotearoa NZ is in the wool sector, which is not one of the major textile fibres consumed here. Closed loop fibre-to-fibre solutions for the major fibres in the market are not economically viable in Aotearoa NZ, nor are the necessarily the next best local life in terms of the value of the resource.

The textile industry in Aotearoa NZ is highly aware of the impacts of their sector. As an industry, it is no longer satisfied with business as usual with business owners and employees committed to creating a better future. Taking a proactive approach industry has come together through the UsedFULLY – Textile Reuse Programme to co-design a low carbon future for the sector in Aotearoa NZ.

Opportunity

In Aotearoa NZ, we send about 100,000T of consumer clothing, uniforms and workwear, PPE, linens and furnishings to landfill each year. The Ministry for the Environment (Aotearoa NZ) calculates landfilled textile emissions at 1.80 CO_2e per kg. This equates to 180,000,000 kgs CO_2e. Vast amounts of money are spent landfilling these valuable commodities, meanwhile virgin resources continue to be extracted to supply the industry and climate impacts escalate.

Textiles are both a priority and an opportunity when it comes to reaching our climate commitments. To effectively divert unwanted textiles from landfill requires large scale science based product pathways that are financially viable. Coupled with data-driven stewardship we can establish solutions that are beneficial to the environment and the NZ economy.

UsedFULLY's research and development has focused on these textiles from a material resource perspective. We started with a feasibility research project with Scion investigating what was happening globally, and then focussed on what opportunities there are to create industrial scale waste-to-value solutions in Aotearoa NZ. The outcomes we are seeking include:

- Alternative solutions to landfilling significant textile feedstock
- Local supply versus importing; as an additive, recycled fibre can reduce usage of other imported materials
- CO_2e savings – contribution to Aotearoa NZ net zero targets by both textile and other industries
- Reducing the chance of microplastics getting into our waterways
- Pioneering waste-to-value research and development and setting foundations for other product pathways for end-of-life resources.

Governing principles

The ultimate goal is longer lasting, better quality, more durable ‘first generation’ clothing/textiles that take longer to enter the waste stream or ‘second generation’ product cycle. We need solutions that can operate at or be viable at different scales, recognising that Aotearoa NZ may never have significant feedstock to feed a large recovery system.

In researching solutions, the principles we have adopted are

- always looking for the “next best local life”, maintaining opportunities as high up the waste hierarchy as possible.
- extending the usable life of an existing resource – this reduces the carbon emissions of sending to landfill, and reduces the need to use new virgin resources.
- when creating a second generation textile product the environmental benefits must exceed the impact of creating it.
- maximise opportunities for local employment / economic benefit – encourage existing reuse initiatives and look to fill the gaps.

Stakeholders

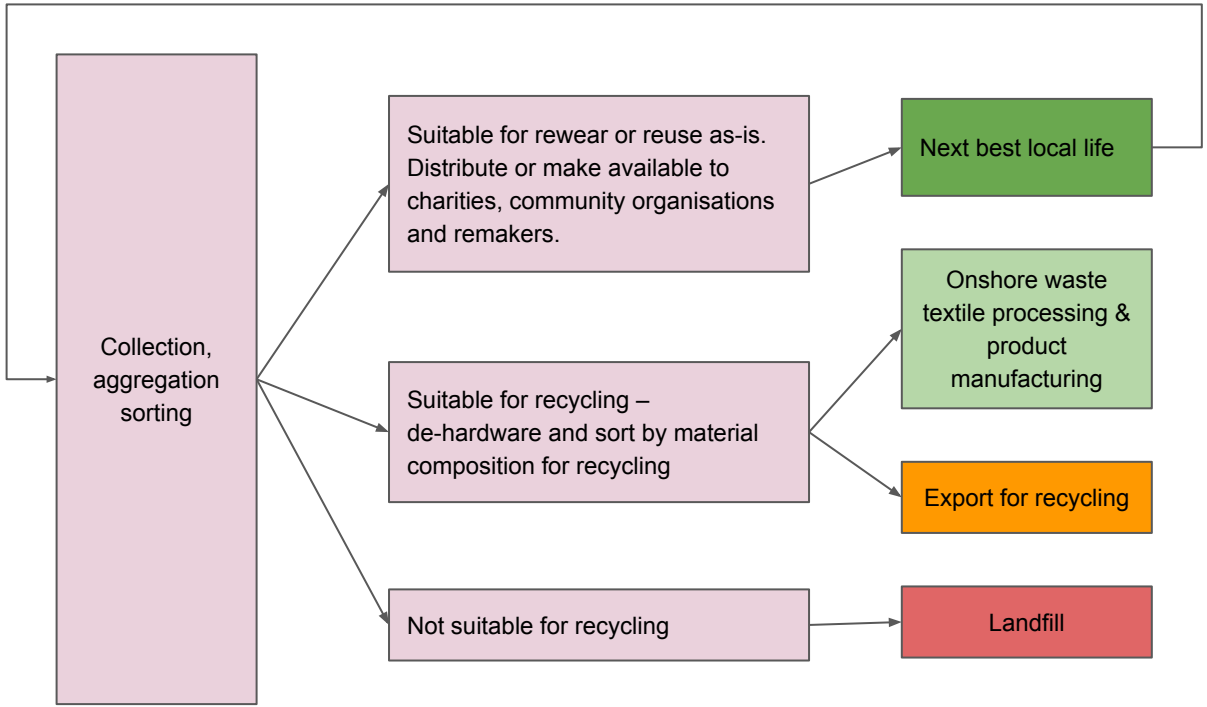
There are multiple stakeholders who benefit from onshore innovation in Aotearoa NZ's resource recovery and waste management value chain:

- The Environment
- Textile Industry
- Industries seeking decarbonisation solutions - particularly in roading and infrastructure
- Central and local government
- The Economy - creating regional jobs and collaborative innovation opportunities
- Members of the Textile Reuse Programme
- Consumers

In addition, we contribute to a more resilient Aotearoa NZ by reducing our reliance on imported goods.

Waste-to-value supply chain

The following diagram provides a simplified view of the supply chain options for end-of-use textile resources.



There is only so much reuse possible with textile and very little is recycled.

Investment is required to create the waste-to-value ecosystem. We need scalable initiatives to optimise reuse and a significant increase in infrastructure supporting recycling solutions.

Textiles composition for trials

In the last 12 months UsedFULLY has completed audits on 12.6T of textiles from organisations who are relatively large procurers of textiles. We also completed an audit on 100kg of Post Consumer textiles.

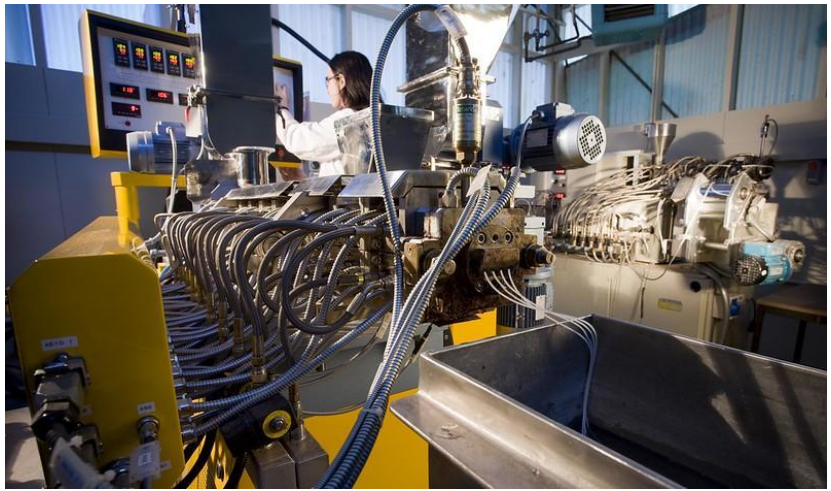
Composition	Organisations	Post Consumer
Polycotton (any blend of only Polyester + Cotton)	31%	18%
100% Polyester	22%	15%
100% Cotton	40%	26%
Other 100% Cellulose (not Cotton)	none recorded	11%
Other fibres / blends	7%	30%

There are already several pathways for cotton – from LYB exporting for fibre-to-fibre initiatives through to commercial composting such as myNoke. For this reason we have focussed our research into onshore solutions for polycotton and polyester, in the knowledge that the processes and infrastructure required will also provide additional opportunities for cellulosic fibres.

Materials science expertise – partnership with Scion

Scion are UsedFULLY's materials science partner, together developing new waste -to -value products and processes, through:

- Fibre refining expertise and refining process development.
- Fibre characterisation.
- Composite testing and development.
- Process techno-economics.
- Material science and analysis, additive manufacturing.



Case Study 1

Polycotton into a recycled roading additive product

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The opportunity

In 2017 we identified roading performance additives as a strong opportunity for recycling textiles in Aotearoa NZ. We discovered that the roading industry imports a cellulose-based product from Europe for use in some asphalt (SMA – Stone Mastic Asphalt).

It's estimated that 160,000T of bitumen is used annually in Aotearoa NZ across asphalt and chipseal. Preliminary lab trials suggest we can reduce bitumen usage in chipseal by 10% to 15% by adding fibre. That's potentially 16,000 to 24,000T annually of fibre with a new purpose in another industry and a product value in the order of $30M annually. This one solution alone could divert around 20% of Aotearoa NZ textiles from landfill.

Polycotton fibre is one of the largest textile types currently going to landfill. Other global recycling initiatives are focused on the separation of textiles back to their constituent fibres. By taking a materials science based approach, our innovation explores the unique qualities offered by the polyester and cotton blend to see what performance enhancing attributes can be leveraged.

The opportunity for this innovation is not limited to Aotearoa NZ. We are already having promising conversations with equivalent parties globally. Building the processing capability to turn unwanted textiles resources (that are not fit for reuse or repair) into industrial products, such as roading, creates the start of a circular economy supply chain that can be used for many products across a number of industries. It is a key component to accelerating onshore circularity in any jurisdiction.

The solution

We engaged Scion to establish a process to take textile to a fine fibre form and make it into pellet form suitable for the asphalt roading mix process. The Research & Innovation Centre of WSP NZ was commissioned to undertake lab-based performance testing pellets derived from cotton, polycotton and polyester textiles against an incumbent cellulose fibre product for SMA. Trials were extended to other types of pavement (OGPA – Open Graded Porous Asphalt, DGA – Dense Graded Asphalt). A like for like comparison between the cotton pellets and the incumbent cellulose with polycotton fibre pellets producing comparable, and often better results to the pure cotton pellets or the incumbent cellulose product.

Fibre is not currently added to chipseal, however with it representing over 80% of the roads laid in Aotearoa NZ we extended the trials to chipseal. The chipseal lab test results showed a significant increase in the adherence of the chips to the bitumen when polycotton fibres were added to the mix, compared to the current control of no fibre, or using cotton or polyester.

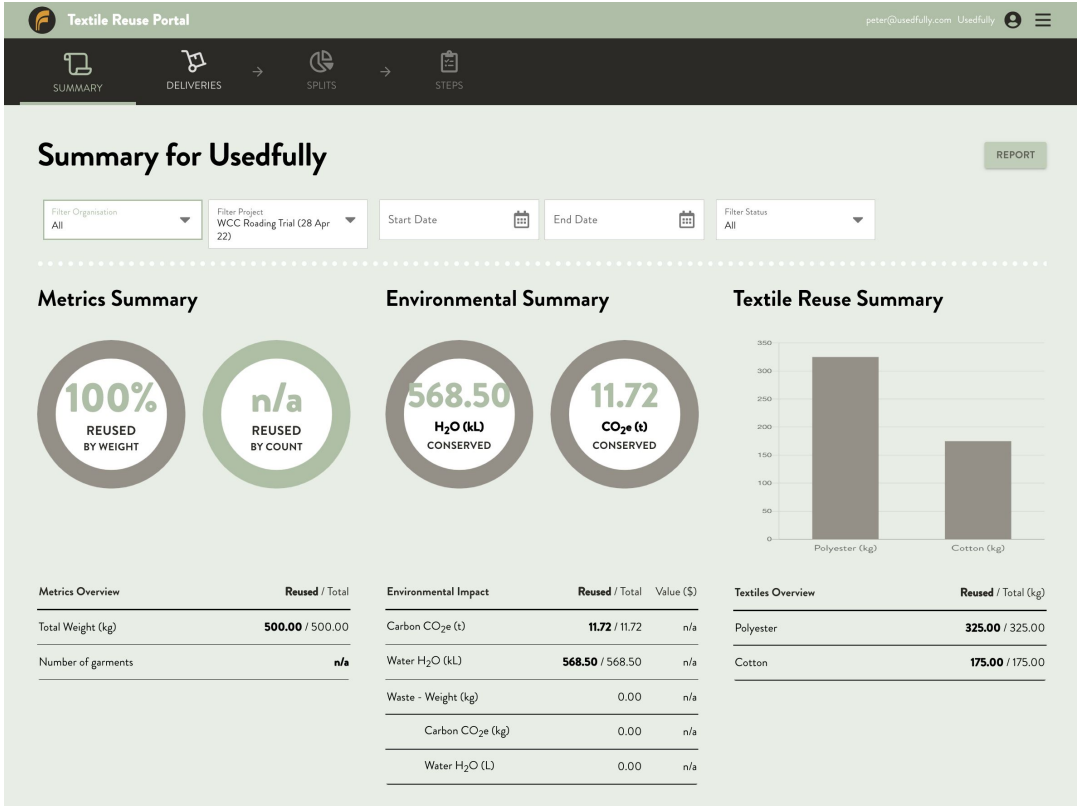
With the prospect of a financially viable solution we worked with various parties to bring a real life asphalt trial to fruition. In April 2022 the first asphalt roading trials were laid in Wellington using recycled polycotton. The next step is further chipseal research with a chipseal trial planned for 2023.

What was polycotton fibre now becomes an intrinsic part of the asphalt or chipseal and does not inhibit the existing practises of reusing end-of-use road into other roading and pavement use.

The process

Wellington City Council
‘StrengthTex’ Roading Trial

Environmental impacts



The trial used 500kg of used polycotton textile. This environmental summary shows the embodied CO_2 and H_2O of the textiles using WRAP UK data.

Increasing the capacity to process & divert 20,000T of polycotton from landfill annually could conserve 470,000T of CO_2e and 23M litres of H_2O.

Our dashboard does not yet show the additional impact of displacing currently imported cellulose; nor the reduction of bitumen needed when applied in new situations not currently using fibre.

Case Study 2

Polyester into recycled “plastic” products

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The challenge

The Aotearoa NZ government and the plastics industry is putting significant resources into solutions that recycle plastics. The Prime Minister's Chief Science Advisor has recommended that the government strategically invest in or incentivise development of systems and infrastructure to deal with our own plastic waste onshore. This has focused on PET, HDPE, PP and LDPE. We recommend petroleum based textiles such polyester (polyethylene terephthalate or PET), acrylic and nylon are included in this list.

In 2017, the Textile Reuse Programme investigated fibre-to-fibre processing technology of polyester in the USA using waste textiles from Air New Zealand uniforms decommissioned in Los Angeles. While the project was successful in removing dye and taking textiles back to raw white rPET pellets, the business case for establishing fibre-to-fibre technology onshore was not viable. It was too early stage technology development, very expensive, not viable for relatively small volumes onshore in Aotearoa NZ.

A key concern of polyester is the microfibre shedding both into our soils and waterways, making its way into our food and ecosystem. In our exploration of pathways for polyester, we are undertaking more research in this area and to find solutions where the polyester is locked into a product that is unlikely to result in degradation in the external environment.

The Solution

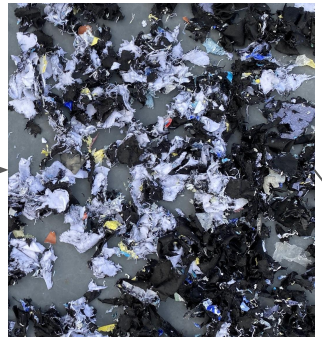
We identified two key opportunities. One was to simply shred polyester and supply it to Critical Design for use in building panels. A higher value opportunity is to create rPET pellets for use in 3D printing and injection moulding. Due to challenges obtaining shredding capacity, we were only able to shred a small amount of material which we made available to Critical Design.

Critical Design have developed a circular economy solution where they take an organisations plastic waste and create panels which are then used in products that the organisation can then purchase and use within their organisation. e.g. counter tops, shelving, tables, stools.

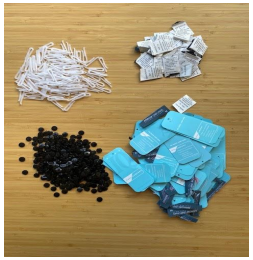
Between 25 – 30% shredded polyester can be added to recycled HDPE (High Density Polyethylene) to provide an accent to the finished product.

Shredded polyester from waste tablecloths and surplus polyester uniforms were shredded and have been provided to Critical Design for inclusion in their next batch of panels. The next step is to work with our Textile Reuse Partners to establish commercial closed loop applications for these panels, ideally within the organisations that provide the polyester. Critical Design are also putting take-back schemes in place to recycle used panels back into their production process.

The process



Indicative end product only



The cardboard was reused at a local school; the soft plastic was put into the soft plastic recycle scheme (New World)

Environmental impacts

We acknowledge that a more ideal solution may be encouraging and supporting the elimination of the use of polyester altogether. However due to the relative financial affordability of polyester compared to other alternatives, organisations such as hospitals are moving towards more polyester linens rather than less. And ultrafast fashion producers such as Shein are also increasing the amount of polyester that will end up in landfill.

With polyester, the greater concern is the shedding of the microfibres into our soils and waterways, with microfibres making their way into our food system and recently found in breastmilk.

Solutions that reuse the polyester into recycled plastic products also binds the polyester fibres into a stable product reducing the shedding of microfibres into the environment.

By finding an alternative use for these products other than landfilling, resources are also conserved, reducing the impact of drawing on new virgin resources e.g. 1T of new polyester has a carbon footprint of 21T CO_2e and a water footprint of 80,000L H_2O.

Conclusion & next steps

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Concluding comments

We believe these open-loop circular economy solutions for textiles waste will be a key contributor to accelerate Aotearoa NZ's transition towards a circular economy. Once the fibre is incorporated into these other industry products, they become an integral part of that product. We actively seek pathways where the use of fibre does not inhibit the circular opportunities for that industry product.

The ecosystem supporting product stewardship and a circular economy for textiles in Aotearoa NZ is growing. Auckland Council naming textiles as a priority product, community resource centres building capability to support sorting, dehardwaring and shredding; sorting and aggregation by the likes of UPPAREL are all encouraging signs towards an ecosystem which will support viable second generation products made here in Aotearoa NZ.

Additional solutions have been identified, trialled and are being scaled for polyester and polycotton with onshore supply chains developed with third party processors. And there are a handful of commercial organisations also working on end-of-life recycling solutions for textile products within Aotearoa NZ. Textile Products and Terra Lana are already well established processing wool offcuts and waste creating insulation, moving blankets and other second generation wool products. UPPAREL are looking to onshore capability in the future to turn used textiles into shoddy, stuffing and fillers.

Examples of onshore waste-to-value products from textiles

Large volume waste textiles
Cotton, Polycotton & Polyester.

Manufactured into **higher value** second generation products through **proprietary** formulas

Building Materials

Injection Moulded Products

StrengthTex Roading

Let’s make clothes UsedFULLY®

Contact Us – UsedFULLY® Low Carbon Clothing System

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