

Citation

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The circular economy and mining workwear waste management in Australia: a case study

Abstract:

End-of-life uniforms and workwear account for around 11,000 tonnes of textile waste in Australia, and only 1% is recycled, with the rest discarded in landfills. Australia's large mining industry operations do not currently engage in responsible employee uniforms and workwear management contributing to the problem of waste. In 2021, the Commonwealth Government of Australia supported the development of a product stewardship scheme to recycle uniforms and workwear to be launched in 2022 and awarded A\$1 million in funding to the Australian Fashion Council to implement a National Clothing Product Stewardship Scheme. These initiatives aim to improve the design, recovery, reuse and recycling of textiles, providing a roadmap to achieve clothing circularity in Australia by 2030 in line with the National Waste Policy Action Plan targets.

The mining industry is the engine of the Australian economy, contributing to economic performance, employment, exports and tax revenues. With the country having some of the largest reserves of iron ore (#1 worldwide), gold (#2 worldwide), silver (#3 worldwide) and lithium (#2 worldwide), the importance of mining and the employment options it provides, will continue to grow, particularly in transitioning to a net-zero economy. Urgent solutions are needed to address the issues surrounding uniform and workwear use to eliminate the substantial amounts of textile waste currently generated by the mining industry.

This paper presents a case study in Western Australia, where half of Australia's mining operations are located, examining the potential for reducing the mining industry's garment waste by applying the circular economy principles. The findings from the case study will assist in better understanding the current practices, key challenges, and potential opportunities in upcycling and recycling mining workwear in Western Australia.

Keywords: workwear, uniform recycling, mining industry, circular economy, case study.

Introduction

Each year an Australian consumes an average of 27 kilograms of new clothes (second-highest amount in the world), and 93% (23 kilograms) of this clothing ends up in landfill (DAWE, 2021). This linear 'take-make-dispose' system is encouraged by the fast-fashion industry and adversely impacts the natural environment. These impacts can be reduced significantly in a circular or closed-loop system where most of the end-of-life textile waste is recirculated within the supply chain through reuse and recycling practices.

Although not driven by fashion but safety, workwear is also part of the current linear system. The Australian workforce generates around 11,000 tonnes of textile waste (workwear), and only 1% is currently recycled, with the rest disposed of in landfills (Australian Government, n.d.). Like many other sectors, the mining industry in Australia does not currently engage in responsible management of employee uniforms or workwear. On the other hand, the economic significance of mining is substantial. In 2021, it contributed A\$206 billion value-added (Granwal, 2021) and employed 271,300 people (Australian Government, 2022). In Western Australia alone there were 149,400 people employed in the minerals and petroleum sector in

2021 (Government of Western Australia, 2021). Employee mobility in the mining sector is very high with 12% of the people who are employed changing jobs by the end of the year (ABS, 2021) requiring new workwear and disposing of used uniforms.

With Australia having some of the largest mineral reserves in the world – iron ore (#1 in the world), gold (#2), silver (#3) and lithium (#2), the importance of mining and the employment options it provides, will continue to grow, including in transitioning to renewable energy and a net-zero economy. Employment is projected to grow by 8.3% by 2025 (Fawthrop, 2020; Australian Government, 2022). Without urgent solutions to address the issues surrounding uniform and workwear use, the enormous amounts of textile waste currently generated by the mining industry will continue to persist.

In recent years, there has been an influx of interest in zero-waste fashion or closed-loop fashion design. Studies have emerged that examined zero-waste fashion design (Nursari & Djama, 2019; Rissanen & McQuillan, 2016), closed-loop supply chain (Hu et al., 2014; Fung et al., 2020) and recycling of textile (Sandvik & Stubbs, 2019; Sandin & Peters, 2018). However, analysis on recycling workwear and uniform are extremely limited and primarily related to the education sector and recycling of school uniforms (Lee et al., 2014; Seo & Shin, 2011). A hierarchy of end-of-life options for corporate apparel (see Figure 1) shows landfills to be the least preferred way of disposing of clothes because of the inefficient use of resources (Russell et al., 2016) and this is where the bulk of textile waste ends up in Australia. Alternative and more resource-efficient solutions along the lines of reuse and closed-loop recycling are most needed for Australia's large mining sector.

As part of an investigative and qualitative research approach, this paper presents a case study in Western Australia, where half of Australia's mining operations are located, examining the potential for reducing the mining industry's garment waste by applying the circular economy principles. Despite a continual increase in environmental awareness around the globe due to climate change, sustainable and responsible management of workwear in the mining industry is still absent in Western Australia. This short case study article aims to start the conversation about taking responsibility and conceptualising a potential way forward for the sustainable management of workwear in the mining industry, which can be scalable and replicable. The findings from the case study can assist in better understanding the current practices, key challenges, and potential opportunities in upcycling and recycling mining workwear in Western Australia towards a circular economy approach.

Methodology

The case study approach is widely used in business, law, policy, and other social science research as a way to understand the essence of complex issues in real-life settings (Crowe et al., 2011; Yin, 2017). It is based on the use of a range of data sources that allow for a detailed description of a particular case; a social enterprise in this study. Although some of the information used in the analysis is quantitative, it only provides a description of the activities whilst qualitative analytical methods, based on interviews with the members of the social enterprise, allow for the development of a deeper understanding of the investigated phenomenon, a particular initiative conducted by the company.

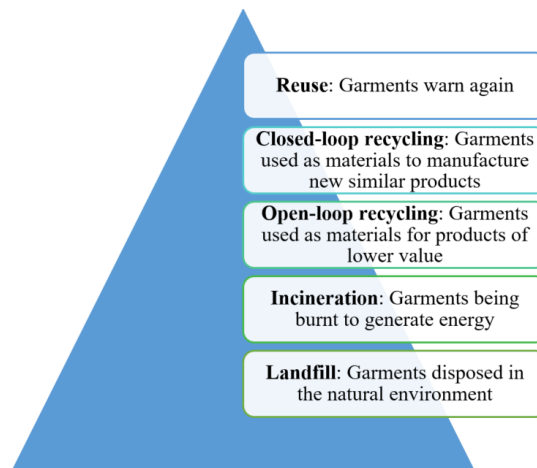


Figure 1: Hierarchy of end-of-life options for apparel with diminishing resource efficiency (adapted from Russell et al., 2016)

Case study: Fibre Economy

Over the past twenty years, there has been a significant rise in awareness of the global impact of textile waste, resulting in the emergence of organisations focused on changing industry and consumer behaviour. A key example is Redress, a Hong Kong-based non-government organisation (NGO) that since 2007 has been a major influencer in the fashion industry’s response to textile waste management. Redress works with designers and large fashion corporations, such as H&M, to change consumer behaviour (Fashion World Online 2019). It has provided an exemplar and inspiration for others around the world to follow, including the Australian social enterprise Fibre Economy.

Fibre Economy’s Second Life Workwear Initiative

Fibre Economic is a start-up social enterprise located in Perth, Western Australia, established in 2019 with the mission to guide both people and industries toward making more sustainable choices when it comes to the way we produce and consume clothing and textiles. As an organisation, Fibre Economy aligns its mission and activity with many of the UN Sustainable Development Goals (SDGs): SDG 4 Quality Education; SDG 8 Decent Work and Economic Growth; SDG 9 Industry, Innovation, and Infrastructure; SDG 11 Sustainable Cities and Communities; SDG 12 Responsible Consumption and Production; SDG 13 Climate Action, and SDG 17 Partnerships for the Goals. A unique feature of Fibre Economy is that it has set its goal as an area of interest in workwear and particularly the mining sector. The industry apparel used in mining is hardly of interest to any fashion brands, however, it offers a range of opportunities within a circular economy model to eliminate textile waste because of the stability and consistency in design and requirements related to materials and comfort.

Fibre Economy is composed of a small team with experience working in the mining industry, and with the international NGO Redress. In 2019, the Fibre Economy team identified the significance and scale of uniform waste, related in particular to personal protective equipment (PPE) which covers high-visibility (hi-vis) workwear. Fibre Economy embarked on further exploring the opportunities identifying the scope and potential for improvement through local solutions. Working with a large mining company, Fibre Economy commenced to provide circular solutions to the workwear challenges through its Second Life Workwear (SLW) initiative, a flagship workwear recycling project developed and tested at a single site in Western Australia. According to one of the Fibre Economy members, the SLW was designed to “keep unwanted workwear out of landfill by facilitating the establishment of collection systems on

mine and operation sites, where unwanted uniforms are separated into a waste stream and where they can then be sorted, de-branded, valorised and redistributed depending on their condition.” Reuse is the top priority under SLW, however, this is associated with many challenges starting from uniform design and cost to requirements for identification and protection. With approximately 1,000 mining sites in Western Australia alone (Geoscience Australia, n.d.), the scale of uniform waste in the sector is significant and presents the potential for high impact to be achieved from modest changes to practices in the supply chain.



Figure 2: Hi-vis workwear. Image source: Fibre Economy

Hi-vis personal protective equipment workwear (as shown in Figure 2) is essential for the safety of employees within the mining industry. The nature of the mining operations means there is a high turnover of both employees and workwear. However, there is no clarity about what happens to the workwear when employees no longer need it. There are currently no services or systems in place in Australia to manage the unwanted uniforms on-site from mining’s 148,000 workforces in Western Australia.

Figure 3 shows a simplified supply chain diagram of the workwear for the mining sector. Fibre Economy estimates that the number of garments being thrown away annually exceeds the figure of one million items. The mining companies’ specific requirements, such as branding (e.g. company logo, name and title of the employee etc.) and safety (e.g. hi-vis), are often incorporated during the manufacturing stage of the garments or at a later stage before the retail phase. Although workwear is a company requirement, sourcing and managing the end-of-life uniform under the existing supply chain system are solely left to the employees – current and past, resulting in a greater chance of garments ending up in landfills (Purnel, 2021). The consequences from the generated textile waste are left to society at large without mining companies or their employees bearing any responsibilities. This is also a market failure situation where the price of the uniforms does not properly reflect the negative externalities and environmental costs associated with their use and disposal. Tax revenues and royalties generated by mining reflect the industry’s exploitation of the Western Australian mineral resources but do not cover the textile waste produced by this industry.

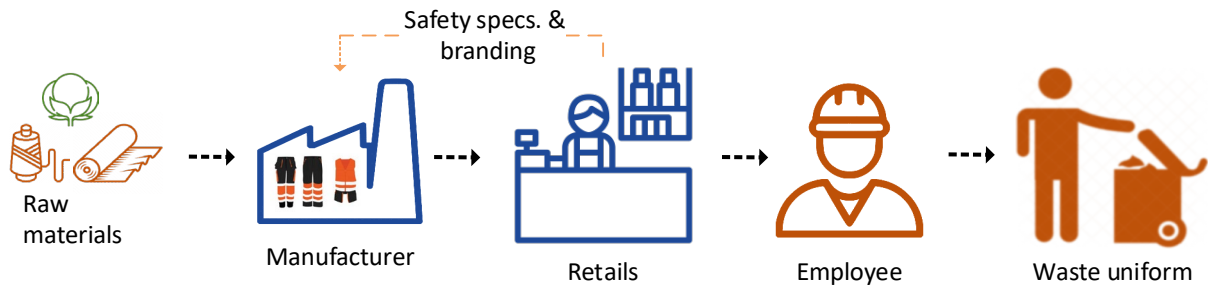


Figure 3: A simplified supply chain of the mining uniform in WA

As part of the SLW pilot initiative, Fibre Economy received 806 kg of workwear from the mining company in Western Australia as a trial to understand the current practices, barriers and potential opportunities. This allowed the company to assess the suitability of the collected garments for reuse or redirecting to the other recycling options (see Figure 1). The workwear collected from the mine site was sorted applying an A-D grading system described in Table 1 which reflects resource efficiency in a diminishing way starting with the best option of reuse for new or near-new workwear.

All waste workwear, including hi-vis jackets and working pants, was hand-sorted (see Figure 4 for jeans) via a range of mechanisms. Garments classified (as shown in Table 2) as being in new and wearable condition (Grade A and B) were donated to recycling stores and charitable organisations. Those categorised as unwearable and damaged (Grade C and D) were donated to fashion design students at Curtin University and other educational institutions across Western Australia with the task of designing closed-loop or open-loop recycling systems. This not only facilitated the application of recycling materials but also supported student engagement in sustainable fashion practices. In order to promote a circular economy, no garments were classified for incineration or landfill.

Table 1: Fibre Economy’s Second Life Workwear trial grading table with diminishing resource efficiency

| | |
|----------------|--|
| GRADE A | NEW OR NEAR-NEW Excellent condition, suitable for take-back systems or secondhand retail <i>NO holes, stains or visible wear</i> |
| GRADE B | WEARABLE Wearable condition, donated to charities with employment initiatives <i>MINIMAL holes, stains or visible wear</i> |
| GRADE C | UNWEARABLE Poor condition, sold to education institutions, artists or designers to be used in upcycling practice <i>MINOR holes, stains or visible wear, fabric still salvageable</i> |
| GRADE D | DAMAGED Unusable condition, redistributed to downcyclers and textile recycling companies <i>MAJOR holes, stains or visible wear</i> |

As part of their studies in the unit Sustainable Fashion, students from Curtin University developed garments which were presented at an exhibition designed to raise awareness of circular fashion featuring examples of the workwear cycle. A pile of workwear garments collected through the SLW project was placed at the centre of the gallery awaiting the process of sorting, styling, or transformation by the designer through the creative application of re-

orientation, recycling, upcycling or repair as illustrated by the Sustainable Fashion student garments presented in the exhibition.



Figure 4: Garment sorting. Image source: Fibre Economy

Table 2 summarises the results from the grading of the collected workwear. A considerable proportion, around 59%, of the collected workwear was found to be in a wearable condition, either new (17%) or fit for reuse/donate (42%). Around 26% were in upcycled conditions to remanufacture other products, such as shopping bags, and only 15% were graded as downcycling, e.g. to be used in new fabrics. Based on current practices and statistics, without the SLW intervention on this particular mining site, 99% (or 800 kg) of the workwear would have ended up in landfill.

Table 2: The proportion of graded workwear (data provided by Fibre Economy)

| Workwear items | New (Grade A) | Donate (Grade B) | Upcycle (Grade C) | Downcycle (Grade D) | Total garments |
|-----------------|---------------------|---------------------|----------------------|------------------------|-------------------|
| Women's Pants | 38 | 181 | 59 | 11 | 289 |
| Women's Shirts | 13 | 0 | 0 | 19 | 32 |
| Men's Pants | 90 | 266 | 215 | 57 | 628 |
| Men's Shirts | 28 | 0 | 0 | 55 | 83 |
| Jackets/Jumpers | 5 | 0 | 0 | 13 | 18 |
| Boiler suits | 2 | 0 | 0 | 2 | 4 |
| Total grades | 176 | 447 | 274 | 157 | 1054 |
| % | 17% | 42% | 26% | 15% | 100% |

Many challenges exist in changing current practices in both the supply chain and the uniform management in the mining industry. Handling uniforms and workwear remains a labour-intensive process and Fibre Economy is developing relationships with local organisations such as Loop (<https://www.loop.org.au/>) and not-for-profit enterprise, Good Sammy Enterprises (<https://goodsammy.com.au>), which has a major garment sorting facility. This will expand their processing potential and the ability to direct the garments to the right stream of end-of-life application.

While Fibre Economy has identified uniform manufacturers who want to effect change in the design and production practices to support a circular economy, their interactions with the local mining industry indicate a lack of concern on the part of these companies regarding the level

of uniform waste that is generated. Indications are that it will take a long-term approach or legislation to affect a shift in responsibility for this textile waste onto mining companies. The SLW pilot initiative indicated that the mining company did not want to bear the cost of changes in uniform production, such as the use of easily removable branding that could significantly improve the opportunity for recycling.

Diverting uniforms from landfill

During the trial, Fibre Economy diverted all collected workwear from landfill or incineration, the two most environmentally detrimental options. The social enterprise company also explored a change from the current product-based linear system of produce-buy-dispose to a service-orientated end-of-life workwear management system based on a circular economy approach. Such a system should capture and manage textile waste directing it to the more resource-efficient options and could be applied broadly to mine and operation sites.

The trial identified that due to the absence of a proper workwear recycling system, opportunities are lost in the context of material utilisation for second-life application, including the possibility of reusing by employees in mining, construction or other relevant industries. As the trial project showed, there are opportunities for moving toward a completely circular system by recirculating the workwear within the supply system – up to 85% in this case, with the remaining 15% directed outside workwear but still reusable for other purposes. This downcycled portion of the workwear (not suitable for reuse and upcycle) can be used, for example, in manufacturing construction products, such as green ceramic tiles, the technology developed by Green Ceramics MICROfactorie™ (SMaRT Centre, n.d.).

The focus of analysis so far has been on resource efficiency however, there are additional environmental benefits to be gained by avoiding textile waste generated by the mining industry and its diversion from landfill and incineration. The Fibre Economy trial figures indicate that the application of the SLW recycling approach has the potential to halve water waste and carbon emissions through the recovery and reuse of uniforms. In the trial case, 707 kg of workwear were diverted from landfill, including 375 kg (53% redistribution rate) of workwear were redistributed. Assuming that only 53% of the collected workwear is reused (6% less than the estimated 59% to allow for losses in the system), this would result in 1.41t CO₂ emissions avoided and 3,426,612l water used to produce workwear saved. The scale of garment waste in the mining industry creates an opportunity through the adoption of the SLW system to contribute towards the mitigation of carbon pollution to tackle the climate crisis and save water in a freshwater-challenged continent, such as Australia.

Discussion and conclusion

Fibre Economy represents a new generation of fashion and apparel activism and the social enterprise is leading the way in the development of awareness and changes in industry practices. In the spirit of SDG17, the company is building partnerships and has recently joined the Curtin University consortium brought together to contribute to the Australian Fashion Council National Clothing Product Stewardship Scheme (Australian Fashion Council, 2022). The SLW project is set to transform the mining industry practices and bring to the fore ownership or responsibility for the application of circular economy practices to workwear.

Figure 5 shows service-based circular economy solutions for the workwear. In this proposed model of management, uniforms are sourced as part of a service, allowing them to recirculate

in the supply chain either for the same purpose or in creating a secondary product market (e.g. green ceramic, bags etc.).

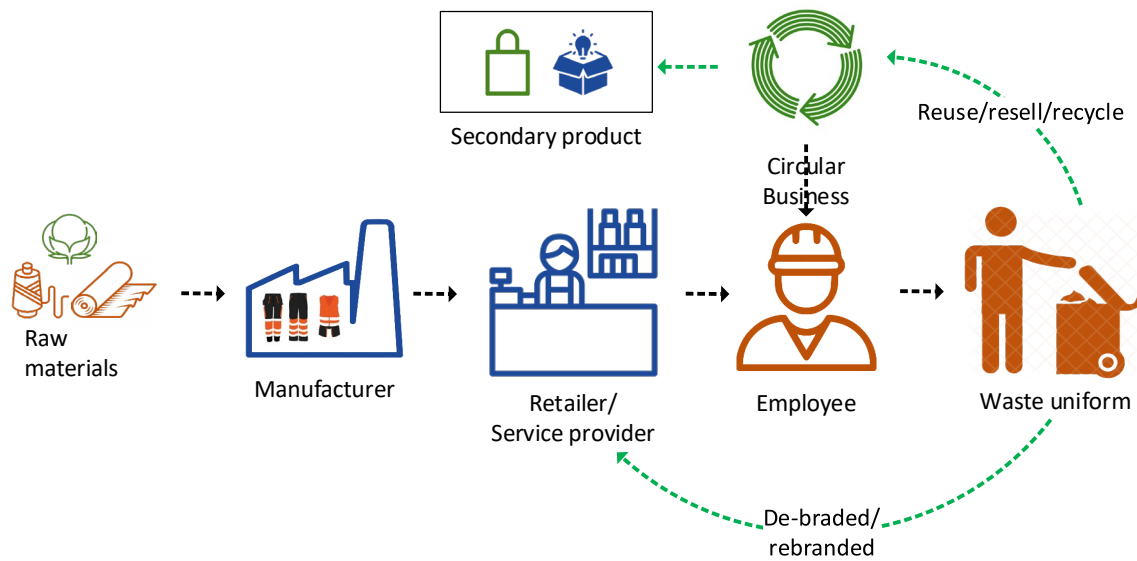


Figure 5: The proposed service-based waste uniform management

We hope that the joint approach and contribution to the Australian Fashion Council’s National Clothing Product Stewardship Scheme with a planned report to the Australian government will assist in affecting a shift of responsibility onto mining companies for the ownership and reduction of textile waste generation. Working jointly across sectors and in partnerships, it is possible to develop complementary strategies to not only further the work of a social enterprise like Fibre Economy, but also to implement a major transformation in the way uniforms and workwear are perceived. The SLW trial demonstrates that a change is possible and can be practically achieved. Better industry awareness combined with government policy disrupting current practices (Marinova et al., 2017) can put in place the framework required for achieving a circular economy in a sector that is ripe for change and transformation.

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