# THE SHIFT TO RECYCLED MATERIAL FOR ELECTRONIC PRODUCTS:

# COMSOL'S PERSPECTIVE IN AUSTRALIA

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## Abstract

Globally the electronic waste crisis is growing rapidly. In Australia, the amount of e-waste created per person in a year is >20 kg while, on a global scale, the estimated growth of e-waste from >53 Mt in 2021 to >74 Mt in 2030 is alarming for both downstream impacts to the environment, people and businesses but also upstream in supply.

Upstream innovations hold a range of opportunities and there is a growing interest by government and industry in focusing more broadly on an ecosystem approach to the circular economy.

Comsol Pty. Limited (Comsol), an Australian manufacturer, importer and distributor of small electronics including cables, chargers, power banks and adaptors, has been collaborating on new innovations to bring to market cables using recycled polymers. This forward-thinking strategy has utilised the Global Recycled Standard certification process to ensure that the materials used in cables are not from virgin sources.

- Recycled Thermoplastic Elastomers is used for the inner and outer casing, along with the plug end - a shift to recycled content from the use of Thermoplastic Elastomers or Polyvinyl Chloride (PVC).
- Internally, the wiring casing has transitioned from virgin PVC to Recycled Polyethylene.
- The recycled resources are sourced from scrap wire, shoes, toys and other plastic products.
- Sorting, cleaning, crushing and removal of impurities, using control testing equipment, occurs prior to the resource becoming plastic pellets that are used in the creation of the cables.

Comsol has >10,000 cables coming to market in 2023. The initial products include consumer facing items, in retail stores, that can enable more awareness of novel innovations and the circular economy through marketing and assurances of the quality supply chain, i.e., by using the GRS logo.

This transition of polymers is a first step toward circular electronics and is currently a cost to business that requires an ecosystem wide step-change toward the use of recycled content, where recycled material is on par or less than virgin.

Despite the material cost differential, one of the big positives in this process is that on floor manufacturing operations have not needed to change to produce GRS cables. This key point can encourage higher levels of participation in a circular economy for small and large electronic products, provided that we continue to communicate the improvements, collaborate with partners and measure the impacts.

## Introduction

Electrical and electronic equipment waste (e-waste) is the fastest growing single waste stream globally[1]. Addressing this situation can provide a range of benefits for social, environmental and economic reasons throughout the supply chain, yet this requires a systemic shift in approach. Much of the issue relates to the reliance on the linear economy model (take-make-waste method) throughout an electronic products life cycle.

In Australia, the amount of e-waste created per person in a year is estimated at 20.4 kg[2] compared to approximately 7.3 kg globally[3]. E-products and e-waste in Australia are expected to grow, per capita, from 20.4 kg in 2019 to 23.4 kg in 2030, a staggering 14% growth in a decade. On a global scale, the estimated growth of e-waste from >53 Mega tonnes (Mt) in 2021 to >74 Mt in 2030 is alarming not only for downstream impacts to the people, the environment and businesses but also upstream in supply. To reduce the social, environmental and economic impacts of this crisis, there is an urgent need to identify, develop and implement solutions that address the root causes of e-waste generation. The main drivers of this problem include an increase in the amount of electronic products being created, in combination with higher discard rates by consumers with greater levels of disposable income (an increase from 2.0% in 2018 to 3.3% at the start of the global pandemic in 2020 in OECD countries)[4]. Furthermore, businesses, in search of greater profit, not designing sustainability into their products exacerbate e-waste generation.

The development of product stewardship initiatives, government commitments and industry innovations are vital to a sustainable transition. From a business perspective, a focus on the following areas provides opportunity to be at the forefront of the transition[5]:

1. incentivise and support product design for circularity;
2. enable producers to increase sourcing of recycled content;
3. transform consumption modes to increase market demand for circular products and services;
4. guide and support new business models for environmental, financial and social triple-win;
5. encourage bring-back by consumers;
6. set up effective collection systems;
7. enable efficiency and transparency in compliant and responsible transboundary movement;
8. strategically plan and install sorting, pre-processing, and recycling operations;
9. increase incentives for investment in recycling technologies and facilities; and
10. integrate and advance decent work in the transition to a circular economy for electronics.

However, there are barriers to participation that must be addressed to accelerate the transition to a circular economy for electronic products. Yet, with barriers there are also a number of potential pathways to accelerate the transition. For example, the use of recycled material in electronic products, particularly low-value and difficult to repair items such as cables is a prime opportunity.

Comsol Pty. Limited (Comsol), an Australian based manufacturer, importer and distributor of cables, chargers, power banks and adaptors provide a case in point of how being nimble and implementing a forward-thinking strategy in this market can present scalable opportunities. At Comsol, we have had a step-change in approach since 2020, after starting operations in 1991, toward a for-purpose approach that champions sustainability in the Australian market. In 2022, we were recognised by the Australian Packaging Covenant Organisation as the Industry Sector Award Winner in the electronics category for small to medium sized business. Importantly for us, the move from packaging made of virgin plastic, e.g., blister packs, to recycled cardboard using plant-based ink, with zero plastic was a first step in a more ambitious strategy. Together with our manufacturing partners in China, we are bringing to market cables made with certified recycled plastic, a first of its kind to be displayed in our national retail partner's stores.

This paper discusses why and how recycled material in electronic cables is beneficial particularly for Australia, a country that has recently implemented circular economy targets at a national level. In doing so, our aim is to highlight how market changes can be driven from smaller locations and in products that are often neglected compared to larger items. We started to focus on cables, as they are ubiquitous in electronics and therefore perfectly placed to lead the transition toward the use of recycled material in electronic products compared to products that are more complex due to their operations or components.

## The Waste in E-Waste

The circular economy is a solution to the current take-make-waste linear model that addresses a range of global issues, from resource depletion to pollution, by valuing the resource being used. The process, that aims to mirror natural ecosystem design[6], illustrates that waste does not need to exist. This situation perfectly juxtaposes the image of landfills, beaches covered in bags, straws, toys and other items, or city streets with piles of mixed organic

and non-organic material in the corner of a sidewalk. What could the linear economy look like for an electronic cable?

At Comsol, we offer over 1,000 different product lines, with one of the most popular being a 1.2 m long lightning to USB cable that can charge and sync any Apple iPhone, iPad or iPod. The materials typically used to manufacture this type of cable are all from virgin sources:

- the outer case is made from Acrylonitrile Butadiene Styrene (ABS);
- the inner casing from Polyvinyl Chloride (PVC);
- the plug uses two material types, stainless steel for the connecter and ABS for a cocoon;
- the inner wires are wrapped in High-Density Polyethylene (HDPE); and
- the other internal materials are copper and aluminium foil.

In total, this product weighs about 22 grams with the polymers being a third of the weight. The product line is manufactured in Guangdong Province in southern China, with the materials for the cable being sourced from local suppliers. It is packaged in a retail box that weighs 18 grams and stored in a larger transport carton together with 99 other identical boxes.

The transport carton is placed on a pallet with many other identical cartons, boxes and cables, loaded onto a truck and sent to a boat port in China. From there, the products travel via sea to a port in Sydney, Australia and then by truck to a warehouse in Western Sydney. The products are later dispatched to locations around Australia. For instance, some products travel almost 1,000 km from our warehouse in Sydney to retail stores in Melbourne. Shortly after arriving in Melbourne, they are displayed on a retail shelf in one of the main shopping precincts of the country's second largest city. Thousands of these items are sold every month nationally. It does not take long for the little white cable to be removed from the hanger display, purchased and taken home for use.

The Australian government commissioned an e-stewardship report, published in 2021, that provides a range of data about the e-product supply chain. In 2019:

- 975,000 tonnes of electronic products were manufactured for use in Australia;
- 8,215,000 tonnes were in use by consumers or businesses - this includes products stored at home or offices e.g., cables in a desk drawer;
- 520,000 tonnes were collected through product stewardship initiatives, take back schemes, council collections or waste management companies with only 58,000 tonnes being dismantled/separated - note that these recovery activities are undertaken particularly for high value material and component recycling;
- 220,000 tonnes of the 520,000 tonnes of recovered products continued their linear journey in metal scrapping; and
- 240,000 tonnes ended in landfill – the tonnes that were exported were not determined[2].

The cable purchased in the retail store in Melbourne is likely to be used between one and five years – many electronic products are used between one and a half years and 13 years, with an average of four and a half years[7] – before finding their way to the collection stage of the supply chain. As a low-value item, retailing for AU$18.98, it would be unlikely to expect that it would find its way to the dismantling stream, or the metal scrapping due to its low-value material components. Instead, the cable would likely join the 46% of material - a total of AU$680 million worth of materials in 2019 - in landfill.

A 22 gram product that has social, environmental and economic impacts throughout its life cycle is a valuable resource, containing material that can be reused, if not to create another cable then into another item entirely. Instead, the little white cable in the landfill becomes e-waste. This offers an opportunity to improve the business practices of the electronics sector while delivering social, environmental and economic benefits.

## Australian Product Stewardship and Circular Economy Perspectives

Product stewardship is a concept that aims at collaborating with all the actors involved in the life cycle of a product, from its design through to its manufacture and sales to its disposal, in order to share responsibility in reducing the environmental and social impacts of the product. It intends to improve the design and manufacturing of a product by employing materials and components that are easier to recover, reuse and recycle.

Australia’s Product Stewardship Centre of Excellence, through their Product Stewardship Gateway, has identified 99 active initiatives in 32 product class categories, including 6 government accredited initiatives. About 44% of initiatives aim to make products more durable, less hazardous and more recyclable, 50% focus on extending product use through repair and reuse, 86% aim to increase collection and recycling of products, and 31% target

all three stages of the life cycle[8]. Of these, eight schemes and seven business initiatives focus on electrical and electronic products (Table 1).

Table 1. Summary of product stewardship schemes and initiatives in Australia[9]

| Product class | Number of collective schemes | Number of business initiatives |
|---|---|---|
| Packaging | 15 | 11 |
| Electrical and Electronic Products | 8 | 7 |
| Plastics | 7 | 1 |
| Clothing Textiles | 1 | 7 |
| Building Materials | 0 | 4 |
| Furniture | 2 | 4 |

The findings illustrate that there is work being undertaken across sectors, and with 13 other schemes in development there is a growing interest in managing material resource flow throughout a products supply chain. There are, however, pitfalls in some of the stewardship actions. Established in 2011, the National Television and Computer Recycling Scheme aims at providing households and businesses access to a service that collects and manages televisions, computers, printers, computer parts and peripherals[10], but does not include the collection of cables. There has been discussion about this scheme expanding but progress is slow, leading to collective schemes, such as the national Mobile Muster accepting phone cables in 2022. Despite this being an important option for the lightning to USB cable, discussed above, there are many other product lines that are not included in this collection, such as, HDMI, fibre optic, and network cables. This highlights that there is such an array of complexities to this situation that it requires a range of solutions rather than a one-size-fits-all approach to help transition toward a circular economy for electronics.

The Australian government has recognised the complexity of this transition and has committed to achieve a circular economy by 2030, including the establishment of an expert group to guide the transition. This promising ambition was announced in November 2022 at *Circularity*, the country's first annual dedicated circular economy conference. Parallels can be drawn to other global initiatives including the European Green Deal that has led to greater interest in managing material flows in a variety of ways, including product passports. Notably, there is a need for government commitment and business initiatives to create change. The diffusion of solar panels in Australia is a relevant example that was incentivised by the government, and market demand has driven the costs down to a point where the renewable energy technology is widely used among homeowners and businesses[11].

## Comsol's Perspective

A similar transition can occur for the circular economy as a whole due to consumer, business and government interest, provided the complex topic is explained in a way that the common citizen can understand. To simplify the process and to address the gaps in the current market for our product types, the team at Comsol are collaborating with a national resource recovery organisation in the development of an electronic waste education program called *Closing The E-Loop*. This program targets students in years 7-9 and provides three core learning intentions:

1. identify the global e-waste crisis;
2. understand the social and environmental impacts of e-waste; and
3. investigate solutions to the e-waste crisis.

Students gain an opportunity to learn through a pre-workshop booklet, an in-person class workshop, as well as a post workshop activity with a goal to create a movement of changemakers who can share their knowledge with family and friends.

Across Australia, and the Asia Pacific region, there is a need to raise greater awareness for product stewardship, particularly for electronics due to the rapid consumer growth. In addition to consumer facing education programs, government commitments or business initiatives that focus on collection and recycling, there is a great opportunity to create wider change throughout a region as diverse as the Asia Pacific by working with manufacturing teams

to design products for sustainability. Improving the life cycle of low-value cables is an opportunity that can provide various benefits.

In 2021, a sustainability department was embedded within our business and we started working with all of our manufacturing partners in China on the transition to sustainable packaging. In 2022, the team at Comsol were introduced to the concept of using recycled material in cables. During the sustainable packaging transition, one of the implemented strategies was to continue discussing and communicating about environmentally friendly solutions, both upstream and downstream, as part of an ecosystem approach to the team's operations. This knowledge sharing approach was a key reason for one of our longer term and most innovative partners to conceive the opportunity of recovering discarded material that can be repurposed into a new cable. Our partner identified that they could utilise recycled polymers to substitute for virgin polymers. Importantly, the materials could be certified to ensure that our sustainability claims were verified by an authorised third party.

The polymers used for making the cables at the manufacturing facility come in the form of small pellets that can be remoulded to form the required shape. The types of materials used are:

- Recycled Thermoplastic Elastomers for the inner and outer casing, along with the plug end - a shift to recycled content from the use of TPE or PVC; and
- the internal wiring casing has transitioned from virgin PVC to Recycled Polyethylene.

For conventional cables, the polymers come from a supplier that sells pellets created from fossil fuel sources. In contrast, for the recycled-content cables the materials come from scrap wire, shoes, toys and other plastic products, sourced from the ocean among other locations. This is a direct reutilisation of a product that has already been created for another purpose. Additionally, by developing and ordering the products for retail stores across Australia, we are supporting the establishment, and potential growth, of the supplier providing the recycled content materials, thereby delivering increased employment opportunities and improved livelihoods. This is a clear implementation of a circular economy for e-products, highlighted by replacing virgin with recycled materials for one of the easiest materials to substitute in a cable, with social, environmental and economic outcomes.

## Recycled Content Solutions

The materials from scrap wire, shoes, toys and other plastic products are manually sorted, cleaned and crushed. Then, a colour sorting machine removes impurities and sorts the repurposed material into a specific batch so that there is no potential mix between the recycled and non-recycled materials at the manufacturing warehouse. The quality of the materials is also assessed by:

1. precise warm baking;
2. sample impact strength testing;
3. horizontal burning testing;
4. hardness testing;
5. tensile testing;
6. density testing;
7. melt flow testing; and
8. data analysis.

These quality assurance activities are assessed by the Global Recycled Standard (GRS) certification scheme from Textile Exchange, which provides third party assurance of quality[12]. This transition and certification of virgin materials to recycled polymers is a first step toward circular electronics and is currently a cost to business (Table 2) that requires an ecosystem-wide step-change toward the use of recycled content, where recycled materials are about the same price per kg or less than that of the virgin materials.

Table 2. Cost comparison of virgin to recycled polymers used for the production of cables

| Product type | Price of product (US$/kg) |
|---|---|
| Thermoplastic Elastomers (TPE) | $4.58 |
| Recycled Thermoplastic Elastomers (RTPE) | $4.63 |
| Polyethylene (PE) | $1.92 |
| Recycled Polyethylene (RPE) | $2.38 |
| Polyvinyl Chloride (PVC) | $2.05 |
| Recycled Polyvinyl Chloride (RPVC) | $2.63 |

Despite the material cost differential, one of the significant advantages of this innovation is that on floor manufacturing operations do not need to change to produce the GRS certified cables. This key point can encourage

higher levels of participation in a circular economy for small and large electronic products, provided we continue measuring and communicating the impacts to the public, government and partners, while collaborating with all supply chain actors to keep on improving practices.

There are other global solutions to reduce e-waste, including the EU Product Passport, but it is important to raise the unique issue for the ubiquitous cables as far as product passports are concerned. Tracking products using product passports is often discussed in relation to using QR codes on products but for small e-products, like the lightning to USB cables, there is limited space to add a QR code on, in the manner it could be done for a fridge. Yet, it is the fridge that is more likely to be collected in a resource recovery stream. Therefore, we believe that currently the best solution for low-value, difficult to repair items such as our cables is a shift toward recycled materials.

## Measuring the Life Cycle of a Cable

Comsol has brought >10,000 recycled content cables to market in the first quarter of 2023 for product launch. The initial products include 8 different consumer facing cable types, to be sold in our partner's national retail stores. Our hypothesis is that our recycled content cables can enable more awareness of readily available innovations and the circular economy through marketing and assurances of the quality supply chain, e.g., by using the GRS logo. Before expanding further on the certification scheme mentioned, it is important to illustrate how we are measuring the impacts of the cables in comparison to conventional products.

Our team is collaborating with an Australian based organisation, Planet Price, that has created a metric that calculates the social and environmental impacts of a product. It uses Life Cycle Assessment (LCA) techniques to calculate impacts such as greenhouse gases, water withdrawals, land use, smog, acid rain, eutrophication and human respiratory effects, caused by particulate matter 2.5. The results are expressed in monetary terms by applying a societal cost, to help procurement and sustainability teams calculate the 'real cost' of products in their supply chain. Determining the environmental and social LCA has been undertaken using a range of analysis and research sources including CE Delft, which has been identified as one of, if not, the best academic research currently available to determine the monetary value or Planet Price.

This evaluation technique is at an early stage of business growth and testing of its tools. At a later stage of maturation our team will be able to share the results. It is important to measure and communicate these studies in order to develop more marketplace participation - both in the use of the materials and measuring impacts. Similarly, it is important to have a discussion about the barriers and opportunities of product certification.

## Barriers and Opportunities

The environmental claim certification scheme that was chosen, GRS from the Textile Exchange organisation, is one of many ecolabels globally available. Others include Australian organisations such as GECA, that work under the Global Ecolabel Network countering greenwashing, the inaccurate or exaggeration of environmental claims, but without a current ecolabel for our type of electronics or capacity to expand into the area. Similarly, the EPEAT ecolabel, a Type-1 ecolabel for technology products, has not provided a specific label for small electronic components, such as cables. These barriers to participation in such schemes led us to certify parts of the overall product in the way that the GRS standard allows. For instance, we can certify the recycled polymers without a need to certify the copper or stainless steel. There are barriers with items such as our power banks though due to the weight of all other parts prohibiting our ability to claim sustainability improvements under the GRS. Instead we could claim it under a lower standard within Textile Exchange's portfolio that does not require 100% of the materials to be recycled as the GRS does.

Ensuring that standards are at the highest possible level is important, which is why only cables are being brought to market at this stage. Similarly, ecolabels and stringent checks across the supply chain by third party certified organisations are required. However, there is a burden and additional cost placed upon all levels of the supply chain to be at the highest standard.

Similar to certifying supply chains for social reasons that aim to limit modern slavery, the hours required to become certified for environmental reasons can be extensive and has been cost prohibitive for some of our manufacturing locations that are looking to develop their own e-products, with GRS certified materials. Yet, there is a need to track and trace the impacts of electronic products for social and environmental reasons to avoid practices that undermine attempts to create an equitable and inclusive circular economy.

Efforts to streamline the process and reduce other barriers to participation are welcomed across the industry. From our experience, there are more businesses in China that are looking to be involved in creating certified products.

It is important to unlock opportunities for all while being able to accurately track the flow, quality and type of materials used throughout the ecosystem.

## Market Drivers: Our Conclusion is for a Beginning Rather Than an End

The shift to using recycled materials for electronic products is one initiative that can help drive a global transition toward a circular economy. It is a viable option for cables. These items, although often neglected, are so embedded in our everyday lives, whether they connect a television to the wall at home, a computer at work or any of the thousands of other examples that span across all categories of e-products.

We are in a central position at Comsol to be launching our new certified recycled-content products, our *Sustainably Connected* portfolio, to market. Similarly, the team are in a relevant place to measure and demonstrate the social, environmental and economic benefits of using products with recycled content rather than virgin polymers. This can be the next step toward truly circular products that only utilise repurposed materials. For us, this sustainable transition was first realised by our move toward sustainable packaging and now to this burgeoning portfolio of recycled cables. It is a small but important foray into a complex world that is in urgent need of a system change.

In Australia, there is a growing interest, now encouraged by our government's 2030 goals, in the circular economy and a broadening of focus from conversations about recycling for sustainability to a holistic circular view. Cables are relatively small products, just like Australia is relatively a small market compared to other regions on the globe, yet both are now at the forefront of this conversation. We can lead. We can innovate, share knowledge and drive change because of these nimble attributes. A small shift in production in China may be driven by our demand that may consequently lead to conversations with other manufacturers and buyers in the global market. This in turn can grow to more opportunities that bring down the price of recycled materials and/or associated certification and is no longer a cost to business.

Change in itself can start small, accelerate rapidly and unlock opportunities that provide benefit to social, environmental and economic outcomes. Comsol's approach can run in parallel to others, like the product passport, but we need to scale up, collaborate with supply chain actors and government officials to collectively drive the shift toward a global circular economy for electronic products where all materials, big and small, are valued as a resource.

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