Australian Government
Department of Agriculture, Water and the Environment

E-PRODUCT STEWARDSHIP IN AUSTRALIA

Executive Report

ICENI
lifecycles.

Executive Summary

Concurrent with the growth in Australia's population and material living standards has been the growth in waste that is generated, including e-waste. This growth in e-waste is expected to continue over the coming years, leading to increasing concerns of the health and environmental impacts of this waste.

To help understand both the current state and the expected growth of e-waste within Australia, modelling was undertaken to develop a quantitative foundation to help inform future policy development and actions.

Modelling e-products entering the Australian economy and exiting as e-waste

There is no single source of truth for data on Australian e-product consumption, e-waste production and end-of-life management trends over time, although various estimates have been produced in academic and other studies.

To produce an up-to-date estimate of the mass of e-products entering the Australian economy and existing as e-waste, a 'stock and flow' approach was employed, based on a methodology published by United Nations University and used in the calculation of the annual Global E-waste Monitor.

Existing data from a variety of sources was used to model a 2019 baseline, and trend data used to generate a 2030 projection. Modelling was undertaken for different product types and aggregated into eight product categories based on shared characteristics.

Once these products reach their end of life, there are three main pathways for e-waste – landfill, metal scrapping (low efficiency recycling processes where e-wastes are shredded for metal recovery) and disassembly/component recycling (high efficiency recycling processes, where e-wastes are dismantled for full material recovery). However, careful consideration had to be given to estimating the amount of e-waste across the different product categories due to limitations in data for some categories, including the absence of data for direct exports of e-waste, and limited and unreliable data for solar PV and battery storage, lighting and other small and large equipment.

Modelling results

In 2019, 975,000 tonnes of e-products were estimated to have entered the Australian market. Around one-third of this was solar PV and battery storage equipment at 333,000 tonnes. 8,215,000 tonnes of e-products were in use, about 8.5 times the amount of product entering the market. In the same year, 521,000 tonnes of e-waste were generated, equating to 20.4kg of e-waste on a per capita basis.

In 2030, 976,000 tonnes of e-products are projected to enter the market, with the stabilisation in consumption driven by the eventual slowing of solar PV and battery storage equipment installation as the market matures, and many products becoming lighter (i.e. made of more plastics and less metals) over time. However, 11,999,000 tonnes of e-products will be in use, about 12.3 times the amount of product entering the market, and 674,000 tonnes of e-waste will be generated, with falls in e-waste tonnage between 2019 and 2030 for TV and computing equipment (-32%) and other small equipment (-15%) offset by large increases in temperature exchange equipment (+66%), large household appliances (+83%) and solar PV and battery storage (+1700%).

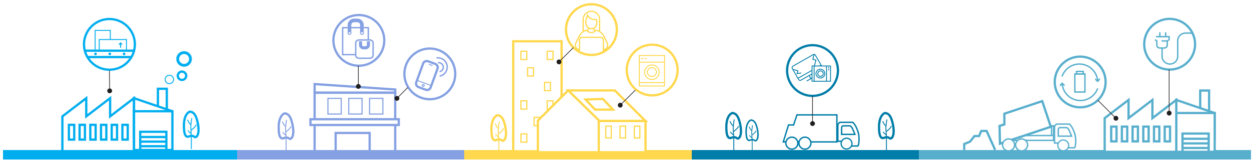
While new solar PV and battery storage installation is projected to plateau, the amount of e-waste from this category increases 18-fold between 2019 and 2030, to 62,000 tonnes. Across all categories, Australians are expected to produce 23.4 kg e-waste per capita in 2030.

e-products and e-waste in Australia		
	2019	**2030**
e-products entering the market (tonnes)	974,000	976,000
e-products in use (tonnes)	8,215,000	11,999,000
e-waste (tonnes)	521,000	674,000
e-waste per capita (kg)	20.4	23.4

Approximately 54 per cent of all e-waste is currently estimated to be collected in Australia, with 80 per cent of this going to low efficiency recycling. However, there is variability in e-waste fate across the eight categories:

- The vast majority of solar PV and battery storage, lighting equipment, and other small equipment e-waste goes to landfill.
- The bulk of e-waste for large household appliances, temperature exchange equipment, and other large equipment go through some form of low efficiency recycling to recover metals.
- Around 50 per cent of TV and computing equipment e-waste goes through high efficiency recycling, reflecting the impact of the NTCRS, while the other 50 per cent goes to landfill.
- Mobile phones are an anomaly with most broken or obsolete phones stocked at home, thereby creating a challenge but also an opportunity to get these phones out of people's homes and recover the valuable materials within them.

E-product/e-waste value chain



Production and manufacturing	Sale and distribution	Use	Collection (4)	Processing
In 2019: 975,000 tonnes		8,215,000 tonnes	520,000 tonnes	
Manufacturers (3) (Mostly overseas)	Retailers	Consumers	Product stewardship	58,000 tonnes: Dismantling/ separation (3) → High value material and component recycling
	Online retailers	Businesses	Manufacturers (takeback)	222,000 tonnes: Metal scrapping
	Service providers, installers	Repairers (1)	Service providers/ asset managers	240,000 tonnes: Landfill (1)
		Refurbishers (2)	Councils (hard rubbish/ kerbside)	Unknown: Export (2)
		Remanufacture (2)	Private waste management companies	

Opportunities

1. Consumer and industry interest in 'right to repair' is high. Repair activities generate local jobs and reduce greenhouse gas emissions.
2. Refurbishing and remanufacturing create local jobs and keep products and materials at higher environmental and economic value than recycling.
3. Recycling activities create local jobs and generate recycled material for manufacturing in Australia. In 2019, **58,000 tonnes** of e-waste were processed in high efficiency recycling systems, and **222,000 tonnes** were shredded to recover metals. Materials worth **$145 million** were captured.
4. The materials in e-waste in 2019 were **worth $820 million**.

Hotspots

1. **$680 million** worth of materials were sent to landfill in 2019.
2. Leakage of waste material overseas is difficult to quantify – environmental and health risks are higher in countries with less stringent waste management.
3. Toxic materials in products create environmental and health risks across the life cycle, and impede circularity.

E-stewardship initiatives

Production and manufacturing
- Use recycled materials
- Design for repairability, disassembly and recycling
- Design out toxic chemicals

Sale and distribution
- Sell and distribute repaired, refurbished and remanufactured products
- Engage and educate users
- Collect e-waste when purchasing new product

Use
- Provide services to extend product life
- Advise consumers and businesses on extending product life and responsible e-waste management

Collection
- Increase collection of e-waste in clean streams for recycling
- Increase sorting that enables some e-wastes to be repaired, refurbished or remanufactured

Processing
- Ban e-waste to landfill
- Increase high value recycling
- Increase onshore recycling of components and particular material streams
- Find local uses for recycled materials from e-waste to create "pull" for recycling
- Investigate and eliminate export of e-wastes that may lead to environmental and health impacts

Material breakdown and value

Using the 2019 data, an estimation of the materials mass and value within e-products was undertaken using average data on material compositions, collected and aggregated into a number of categories: plastics, glass and metals (broken down into ferrous, non-ferrous, precious and speciality). This provides vital new information to policy makers and industry.

While there is significant variability in the material composition of each of the eight product categories, overall:

- Ferrous metals make up the largest material by weight, accounting for 300,000 tonnes or 58 per cent of total e-waste.
- Plastics account for 74,000 tonnes or 14 per cent of total e-waste, although the large variability among different products and presence of chemicals of concern that can be hard to detect make them difficult to recycle. Plastics hinder the economic viability of e-waste recycling and are an important area for future research.
- Non-ferrous metals account for 39,000 tonnes or 7 per cent of total e-waste.
- Glass was estimated to represent 50,000 tonnes of e-waste, although variability in composition and low re-use value create some challenges for recycling.
- Only 25 tonnes of e-waste was precious metals, although metallurgical processes exists to extract these valuable metals from e-waste, with another 800 tonnes (less than 2 per cent in total) made up of specialty metals.
- Other materials accounted for 81,000 tonnes, or 16 per cent of the total. Most of these were unable to be characterised as part of the analysis – hence could be the subject of further research – and some were materials such as concrete in washing machines that do not fall into the typical metal, plastic or glass streams.

By 2030 the amount of all e-waste material types are projected to increase, consistent with the increase in e-waste generally. Glass is projected to increase the most – 171 per cent – driven by the considerable growth in solar PV and battery storage e-waste.

Based on current commodity values on the global market, the potential value of all material found in Australian e-waste in 2019 amounted to about $820 million, with the current recovered value estimated at $145 million, amounting to only 18 per cent of the total value. A cost-benefit analysis would be required to better understand the economic potential of the e-waste recycling market.

The presence of chemicals of concern - including in historic stocks of e-products - impedes the viability of recycling. For example, recycling of e-waste plastics needs to either remove substances of concern at the source (sorting), treat them, or find safe uses of the recycled material that may contain traces of toxicity. This is a considerable challenge for the financial viability of systems.

Environmental and health impacts

E-products contain a wide range of potentially hazardous substances, from lead contained in cathode-ray tube glass, to mercury in fluorescent lamps.

Chemicals of concern contained in e-products pose a wide range of health risks to workers involved in manufacturing, repairing and recycling. When not managed appropriately, these substances can leak into the environment, potentially harming wider communities and ecosystems. In Australia this is of concern in the informal recycling/repair sector and in illegal dumping.

The unmonitored and poorly or unregulated waste recycling facilities (dumps and landfills) in developing countries elevates health and environment risks associated with imported e-waste, with children working in the informal waste sector particularly vulnerable to the chemicals of concern contained in e-waste due to their smaller size, less developed organs and rapid rate of growth and development.

Greenhouse gas emissions

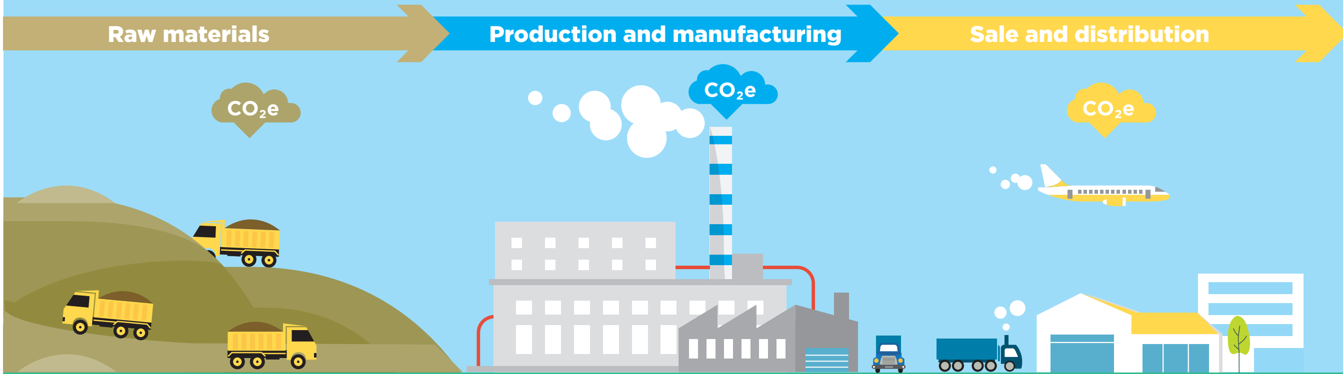
The greenhouse gas emissions associated with the supply chain of e-products across all eight product categories at different life cycle stages was modelled using the best practice, consumption-based Life Cycle Assessment (LCA) methodology. This methodology considers the impacts across the whole supply chain, irrespective of whether they occur in Australia or overseas. Based on the modelling and subsequent analysis:

- An estimated 9 million tonnes of CO_2e was associated with manufacturing and importing e-products that were purchased in 2019. Embodied greenhouse gas emissions of e-wastes in 2019 were about 5.6 million tonnes of CO_2e, with TV and computing equipment contributing 41 per cent of this total.
- By 2030, embodied emissions associated with e-products entering the market are forecast to increase by 13 per cent, to just over 10 million tonnes CO_2e, and embodied emissions in e-wastes are forecast to increase by 25 per cent, to 6.8 million tonnes CO_2e. TV and computing equipment is responsible for a quarter of these embodied emissions.
- Emissions associated with landfilling and 'recovered' through recycling are both immaterial in comparison to the emissions associated with manufacturing these products.
- The management of e-waste in 2019 resulted in the emission of 55,000 tonnes of CO_2e, generated from landfill (7,300 tonnes CO_2e) and recycling activities (47,600 tonnes CO_2e). However, recycling was estimated to recover the equivalent of 860,000 tonnes CO_2e – which more than compensates for the 'investment' in processing e-waste.
- The major limitation of recycling is the inability to recover the greenhouse gas emissions 'invested' in transforming materials into complex products, highlighting the importance of considering e-stewardship strategies to extend product lifetime such as reuse, repair and refurbishment of existing products.

E-stewardship and greenhouse gas emissions

Greenhouse-gas emissions are generated across the life cycle of e-products. Some of these emissions happen in Australia (such as the use phase) and some happen overseas (such as most of the manufacturing).

'Embodied greenhouse gas emissions' is the sum of emissions generated during mining, processing, manufacturing and distribution of e-products.



2019

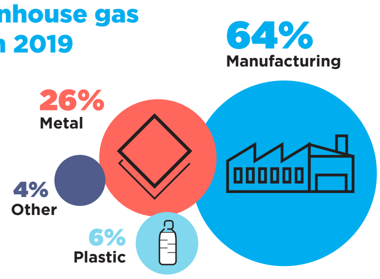
9 million tonnes of CO_2e were emitted in manufacturing and importing the 975,000 tonnes of e-products that Australians purchased, that's 20% more than the annual emissions from the Gladstone coal power station in Victoria.

by 2030

The embodied greenhouse gas emissions in e-products are expected to increase by 13% to just over 10 million tonnes CO_2e.

Source of embodied greenhouse gas emissions in e-products in 2019

Around a third of these emissions come from making the materials and two thirds from transforming these materials into the e-products themselves.



Greenhouse gas emission savings through recycling

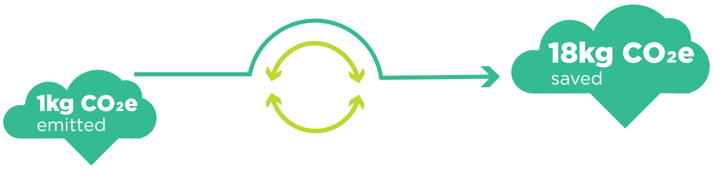
Previous studies have demonstrated that in Australia

recycling of **1 tonne** of mixed TV and computer waste can avoid the emissions of **1.2 tonnes of CO_2e**

recycling **one** mobile phone can avoid the emission of **386 grams CO_2e**

Recycling processes emit greenhouse gases, but result in much greater savings through secondary material recovery.

On average, for each kg CO_2e emitted during recycling processes, 18 kg CO_2e is recovered through the production of secondary material.



How can 2030 greenhouse emissions be improved?

by increasing recycling to 80%

+

shifting to higher value recycling practices increases the net benefits of recycling to

= 2.5m tonnes CO_2e 159% improvement

by avoiding waste in the first place, increasing product lifespans by 10%

=

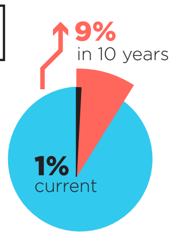
reduces the embodied carbon emissions of e-products entering the market by 1.2m tonnes CO_2e

Solar PV and battery storage

Solar PV and battery storage provide clean energy for Australians - with the benefits for the climate outweighing the manufacturing and disposal costs. In 2019, more than a third of electrical and electronic products coming into the Australian market were solar PV and battery storage. A handful of recyclers are already collecting them for reprocessing.

How big is the challenge?

Today, solar PV and battery storage make up 1% of e-waste. In ten years, this will increase to around 9% - an 18-fold increase by weight.



2019

Solar PV almost **3,800 MW** capacity

Battery storage almost **210 MWh** capacity

= **333,500 tonnes** of material: more than **6 Sydney Harbour Bridges.**

was installed in Australia: that's enough capacity to **power 1.1 million** households

by 2030

Solar PV and battery

62,000 tonnes

of e-waste from solar PV and battery storage wil be produced: that's **2 Airbus A380s every week**

2019 - 2030

Solar PV almost **36,000 MW**

Battery storage over **13,000 MWh**

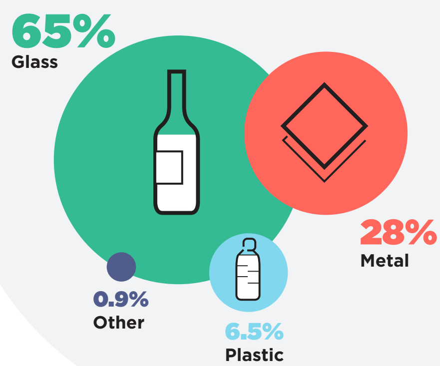
capacity will have been installed

Almost 300,000 tonnes of e-waste from solar PV and battery storage will have been generated

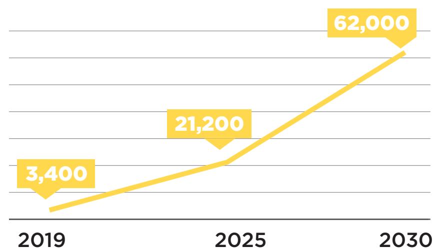
Solar PV and battery storage products typically last 10 to 20 years

10 to 20 years

What materials are in solar panels and storage systems?



Increase in e-waste from solar PV and battery storage systems over time



tonnes of e-waste over time

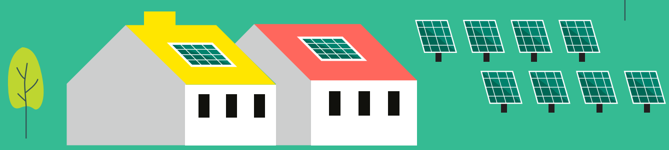
E-waste opportunities

$4.6 million

is the value of materials contained in waste solar PV and battery storage systems in 2019.

Valuable materials

like copper, silver and silicon can be extracted for high-value use in industries such as electric vehicle batteries.



E-waste impacts

Hazardous materials

such as lead and tin – present in the end-of-life panels can cause pollution and health issues if released into the environment.

2,200 tonnes of glass and 900 tonnes of metals

were contained in waste panels and batteries in 2019, among other materials. These e-products come with an embodied carbon footprint of **27,000** tonnes of CO_2e – as much as almost **9,000** cars. Recycling these recoups carbon emissions and avoids using more finite resources.

Increasing recycling and product longevity

Two scenarios were explored in the 2030 modelling to understand potential benefits of different e-product stewardship strategies, noting however that they are not necessarily mutually exclusive or the only options:

- Increasing recycling of e-waste from 54 per cent to 80 per cent, in line with National Waste Action Plan targets, and increasing high efficiency recycling systems.
- Extending e-product life spans by 10 per cent.

Improved recycling would result in an additional $440 million worth of materials recovered, and 340,000 tonnes of e-waste being dismantled for high value recycling - meaning more local jobs.

Increasing product life avoids the generation of 60,000 tonnes of e-waste at the source.

Both of these scenarios radically increase CO_2e emission savings: extending product life would save 1.2 million tonnes of CO_2e and improving recycling systems 2.5 million tonnes of CO_2e.

Data gaps and future research opportunities

The modelling used to inform this report is based on international best practice guidelines and draws upon up-to-date data from a variety of Australian and international sources.

As for any model, assumptions are made to compensate for knowledge gaps, and certain data points are less robust than others. These areas can be improved for subsequent iterations of modelling – and provide direction for future research to inform policy around e-stewardship. Suggested improvements are:

- More data about the local manufacturing of electronics would be useful to inform the modelling, and also for engagement purposes. The model assumed no local manufacturing, however stakeholder interviews suggest there is a healthy local lighting equipment manufacturing sector.
- The model uses 'non-EU' parameters from the e-waste statistics guidelines to estimate the probability of failure, and hence product life. While this is accepted best practice, research to evaluate the appropriateness of these factors for the Australian context and develop bespoke factors where required would improve the accuracy of the model, particularly in respect to solar PV systems.
- Improving data around repair, reuse and resale activities to better understand how e-products are kept in the economy before becoming e-waste. This would improve the accuracy of model results and help inform policy around these 'higher value' circular economy strategies.
- For most product categories, there is a lack of formal data collection systems tracking their collection and treatment at end-of-life. Collection of data on different types and amounts of e-waste processed by metal scrappers would address this data gap.
- The practical impact of state-based landfill bans on diverting waste into recycling systems warrants further investigations. In the absence of reliable data, the model assumes that 50 per cent of smaller equipment is diverted from landfill in states where a ban is present.
- Materials that were characterised as 'other' counted 16 per cent of the total. Further research would help reduce the uncertainty related to this part of the model.
- Regarding 'leakage' of e-waste overseas – potentially to informal recycling – reliable data is difficult to obtain. As a result, data on 'leakage' was not included in the model. Creating a separate category for e-waste as part of the Australian Harmonised Export Commodity Codes and investigating informal sources of leakage would help better understand the current picture.
- Finally, the amount and types of chemicals of concern found in e-waste in Australia is currently poorly understood and relies on international data. Research focusing on Australian e-waste could help better understand risks.

Conclusion

This report has provided up-to-date evaluations of the amounts of different e-products placed on the market and e-wastes generated annually in Australia today (2019) and over the next decade (2030), using a model developed on international best practice frameworks. For the first time, detailed breakdowns of the materials in different product categories have been established and used to model the value of materials: both in terms of dollars and the embodied greenhouse gas emissions. Health risks related to chemicals of concern have also been investigated.

There is an opportunity to continue to improve the model as new and more robust data is collected, enabling updating of estimations and testing of new scenarios.