SMART ENERGY COUNCIL
STEWARDSHIP WEBINAR SERIES - Webinar 1

Solar Recycling & Material End Markets

26 August 2025

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ACKNOWLEDGMENT
OF COUNTRY

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SOLAR STEWARDSHIP

An industry fighting to do the right thing

Solar Stewardship Opportunity
WHY NOW?

Market Estimates - 2043

Difficult to forecast

AVPI data as the source.

https://pv-map.apvi.org.au/postcode

Installations by size by postcode by year and projected estimated decommissioning volumes based on the following assumptions -

Waste Arising Cycle

- Installation losses - 1%
- In Service - incl Warranties - .05% (?)
- Commissioned life
    i. CE - 10 years

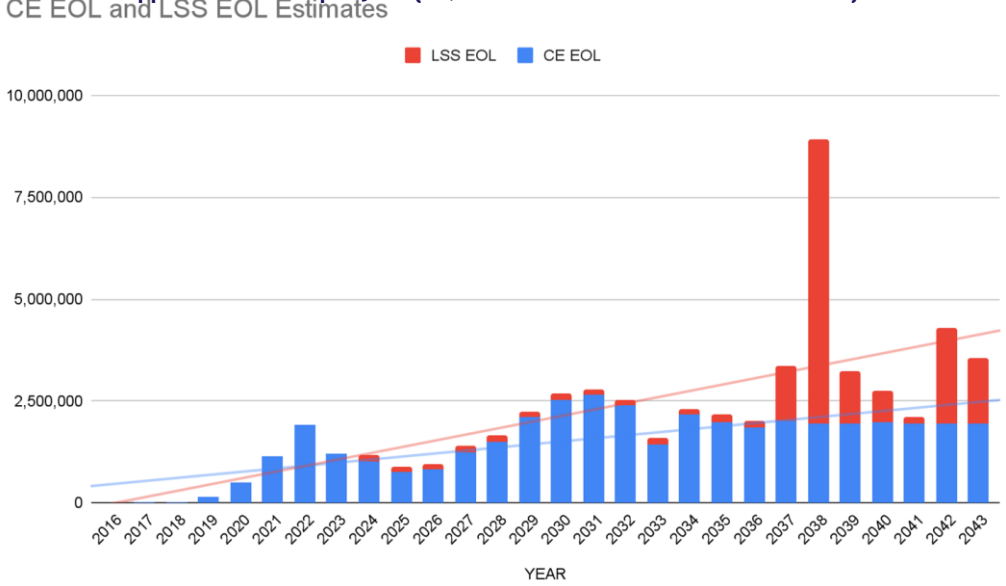
    ii. LSS - 20 - 25 years

Module Power output assumptions to estimate units per installation - starting at 180w to 250w average

Queensland - End of life modules forecast to 2043

47 Million modules - 31m Consumer Energy - 16m Large scale and Commercial (940 Million Tonnes)

2024/25 - approx 1.2 million per year (24,000 tonnes = 1000 semi trailer loads)



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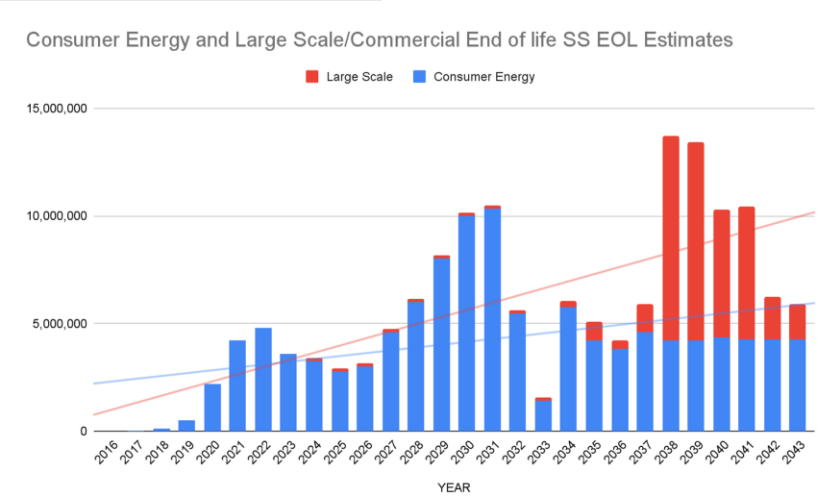
National - End of life modules forecast to 2043

145 Million modules - 134m Consumer Energy - 11.2m Large scale and Commercial

(2900 Million Tonnes)

2024/25 - approx 3.4 per year (68,000 tonnes = 2850 semi trailer loads)



What is the opportunity for Queensland & Australia?

Manufacturing

$1 Billion in investment

Employment

550 to 3000

Resources

$6.5 Billion

It's not a Tech-waste problem, it's a Demand problem,

and an urban mining priority.

Critical Minerals Demand Megatrends

Critical Minerals Demand Megatrends

The Four Converging Forces of Demand

The 21st-century economy is being reshaped by four fundamental drivers, each compounding the demand for raw materials.

1

Population Growth

The addition of another 2 billion people by 2100 creates a massive, growing floor for new aggregate demand.

2

Decarbonization

The green energy transition is profoundly metal-intensive, from solar panels to the electrification of transport.

3

Digitization

The exponential growth of data centers and AI infrastructure requires vast amounts of conductive metals.

4

AI-Enabled Robotics

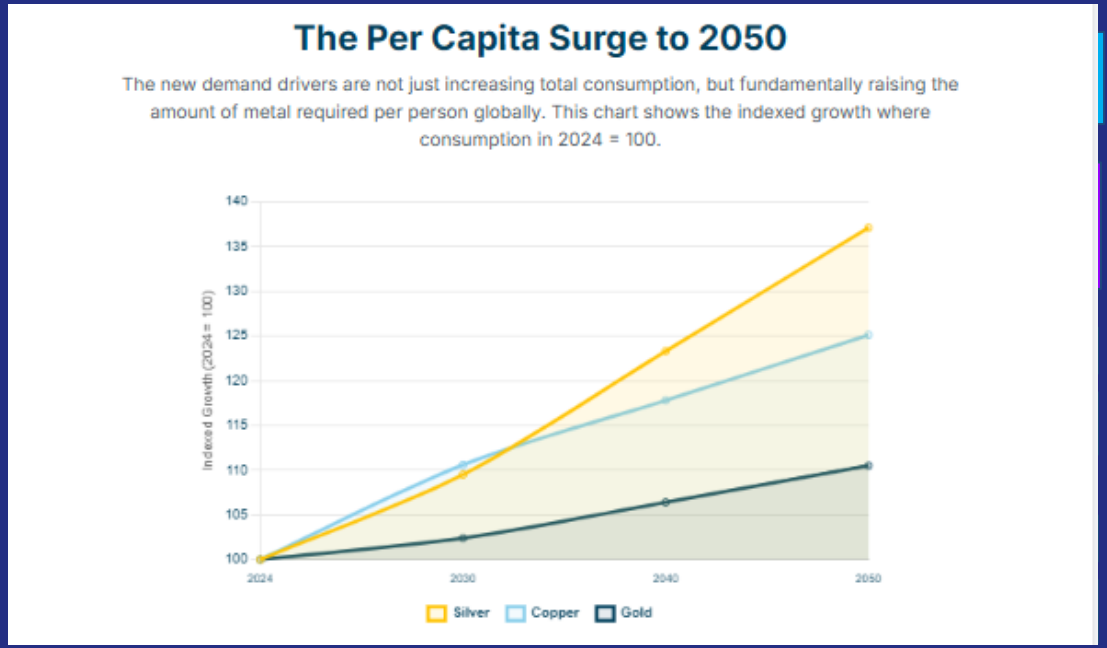
The coming wave of autonomous robots represents a new, step-change in demand for copper, silver, and gold.

Consumption Multiplier

More People

Increased Consumption Capacity

New Emergent Technologies



Decarbonisation Technologies

Solar PV

Requires vast amounts of **Silver**, Copper, and Silicon.

Wind Turbines

Intensive users of **Copper** and Rare Earth Elements.

Electric Vehicles

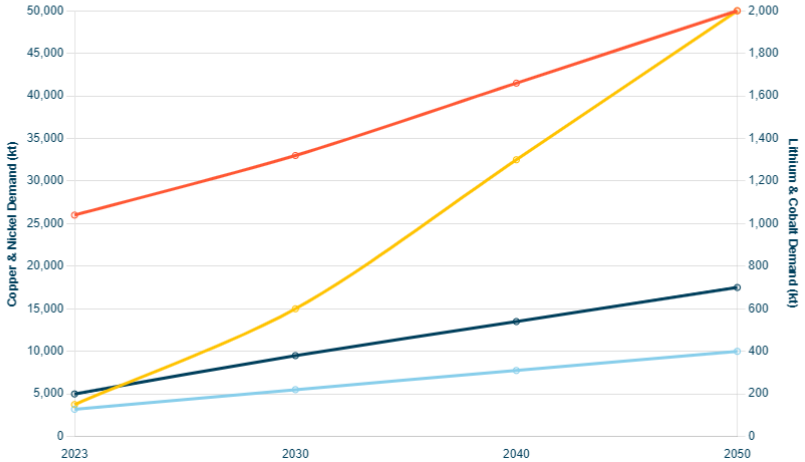
Demand is driven by **Lithium**, Cobalt, Nickel, and Copper.

Battery Storage

Reliant on **Lithium**, Cobalt, and Nickel for grid-scale power.

Projected Growth in Mineral Demand for Clean Energy

Limiting global warming to 1.5 °C requires a rapid and massive increase in the supply of key minerals. This chart shows the projected total demand trajectory for essential decarbonisation materials to 2050.



Digitalisation

5G & Connectivity

Advanced infrastructure needs **Silver** for its superior conductivity.

Consumer Electronics

A vast and growing baseline of demand for a wide range of critical metals.

Data Centers

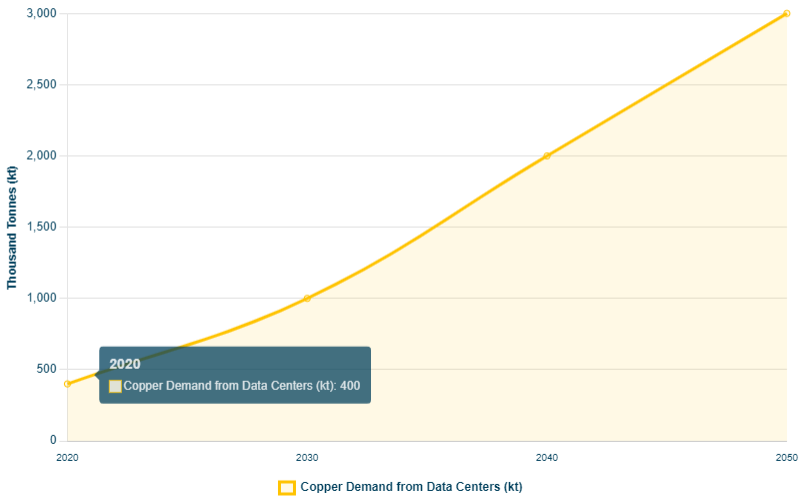
The factories of the digital age, requiring immense amounts of **Copper** for power and cooling.

Artificial Intelligence

High-performance computing relies on **Gold** for reliable, high-speed connections.

The Copper Core: Powering the Digital Revolution

Copper is the workhorse of the digital economy. Demand from data centers alone is projected to surge as the world's hunger for data and AI processing grows exponentially.



AI enabled Humanoid Robotics

Copper: The Muscles

~15 kg

Essential for wiring, high-performance motor windings, and power distribution.

Silver: The Nerves

~25 g

Critical for high-speed computing, advanced sensors, and flexible circuits.

Solar Modules

50 Billion

Projected Global Units by 2050

Total Metal Required:

90M Tonnes of Copper

750k Tonnes of Silver

Electric Vehicles

2 Billion

Projected Global Fleet by 2050

Total Metal Required:

166M Tonnes of Copper

80k Tonnes of Silver

Energy Storage

50 TWh

Projected Global Capacity by 2050

Total Metal Required:

100M Tonnes of Copper

2.5k Tonnes of Silver

AI Humanoid Robots

1 Billion

Projected Global Fleet by 2050

Total Metal Required:

15M Tonnes of Copper

25k Tonnes of Silver

1k Tonnes of Gold

Data Centers & AI

500 GW

Projected New Capacity by 2050

Total Metal Required:

3M Tonnes of Copper

5k Tonnes of Silver

500 Tonnes of Gold

5G & Connectivity

50 Million

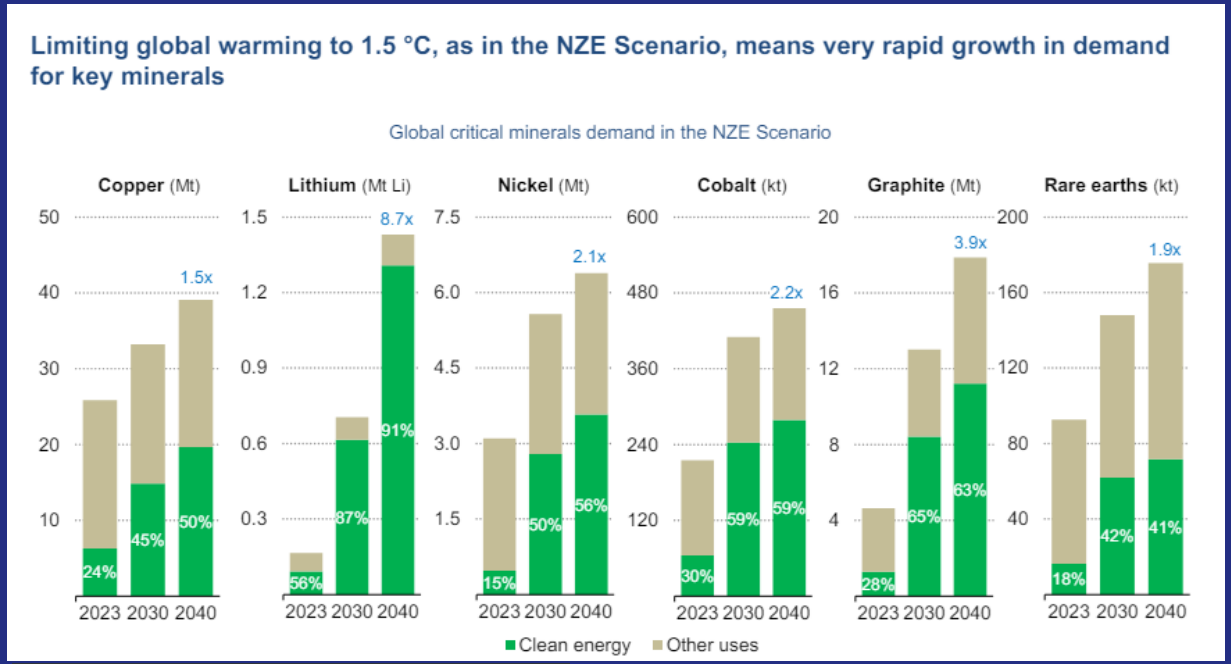
Projected New Base Stations by 2050

Total Metal Required:

2.5M Tonnes of Copper

5k Tonnes of Silver

Massive increases in materials



IEA - Global Critical Minerals Outlook 2024

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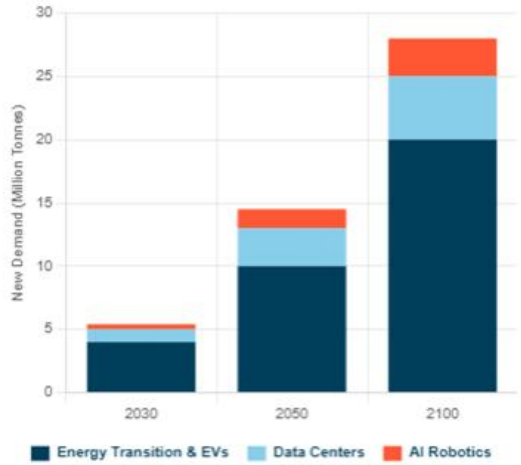
Do we have enough?

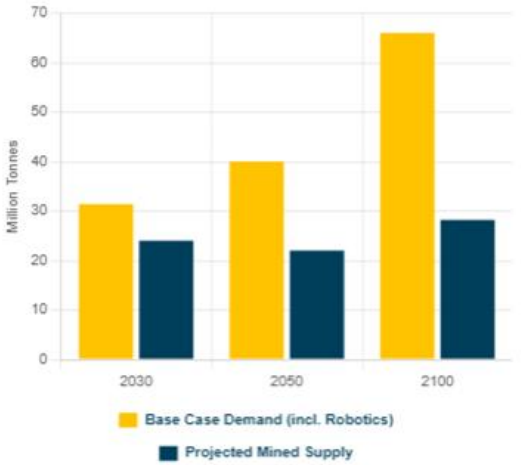
Copper: Primary supply deficits

Future Demand Breakdown (Million Tonnes)



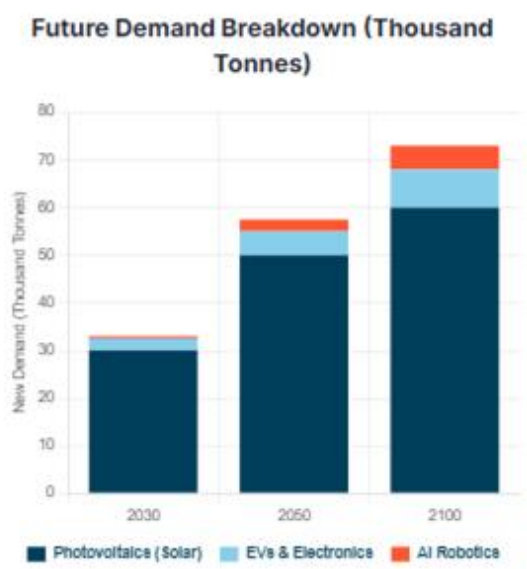
Robotics will become a major new consumer of copper, adding to the already immense demand from the energy transition and data center expansion, creating unprecedented competition for supply.

Projected Supply vs. Demand (Million Tonnes)

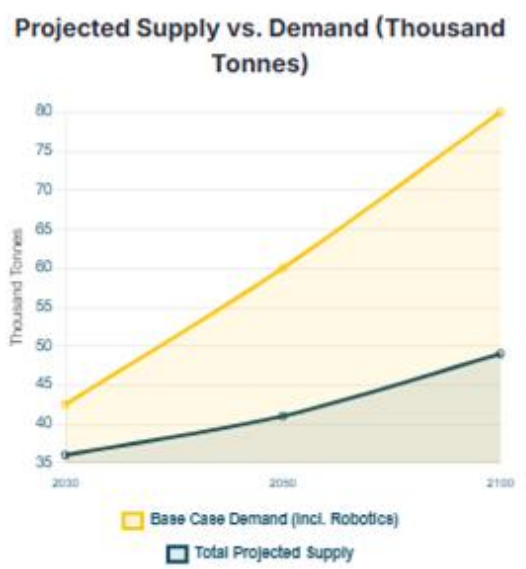


With robotics demand layered on top, the structural supply deficit for copper becomes even more severe. The gap between what the world needs and what mines can produce grows to a critical level.

Silver: Primary Supply Deficit



The explosive growth in solar panel production remains the primary driver of silver demand, but the addition of a scaled robotics industry creates another significant, non-negotiable demand vector.



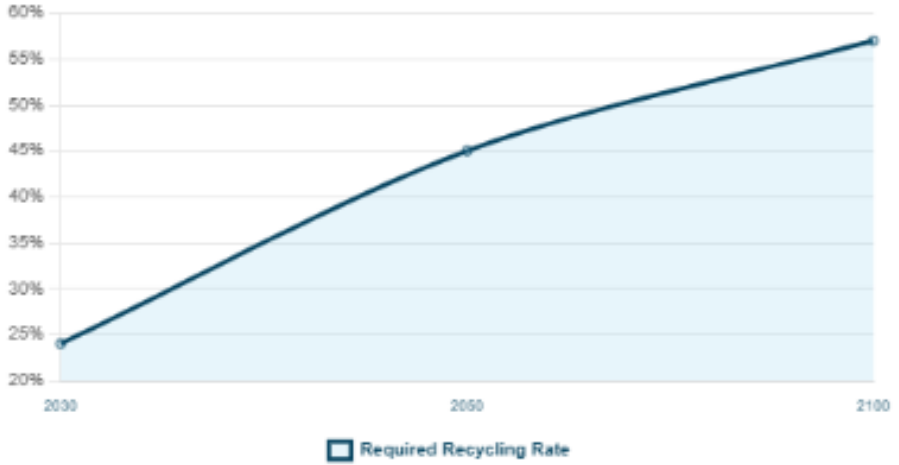
The silver market is already in a structural deficit. The addition of robotics demand ensures this deficit will grow substantially larger, making new primary and secondary supply critically important.

The solution is Urban Mining

Recycling: Copper

2024
24%

2050
45%

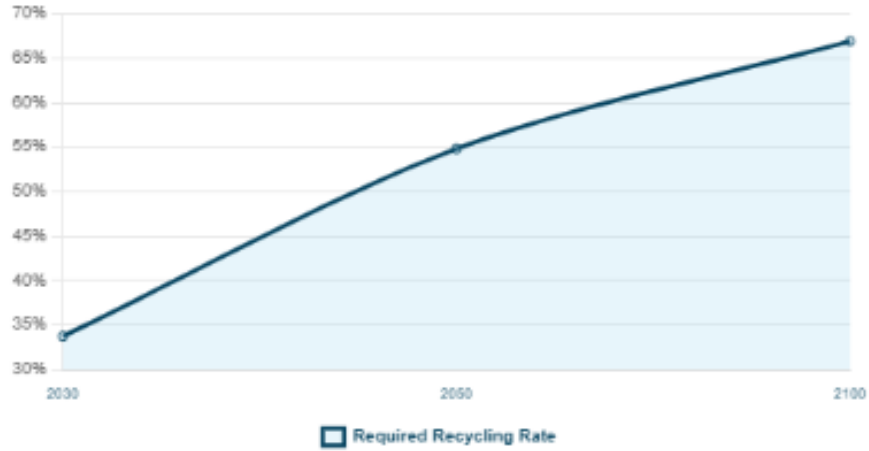


To close the supply gap, the world must dramatically increase its reliance on recycled copper. By 2100, over half of all copper consumed will need to come from secondary, recycled sources.

Recycling: Silver

2024
33%

2050
65%

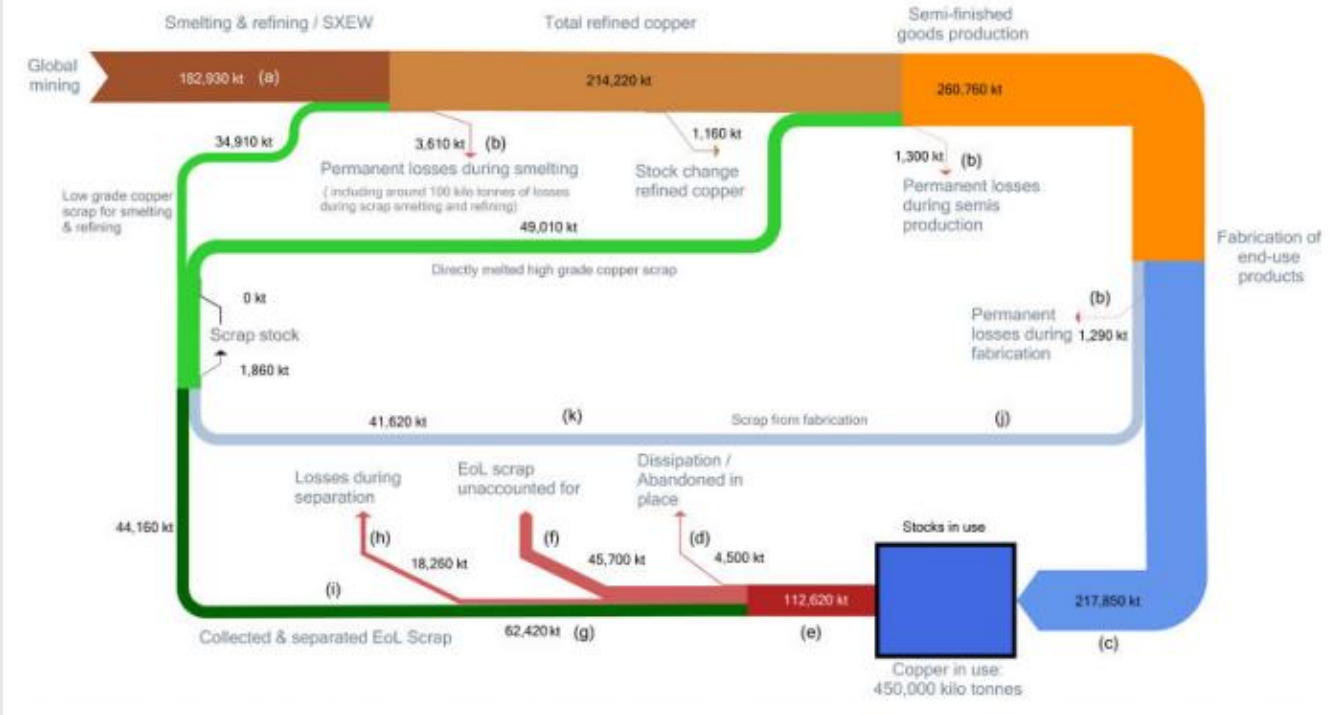


The need for recycled silver will become acute. By mid-century, over half of all silver will need to come from recycled sources to meet demand from green tech and robotics, a rate far higher than today.

Is this actually possible?

Long term stocks and flows

FIGURE 3: Global Copper Stocks and Flows 2009 – 2018 (ICA/Fraunhofer, 2020).

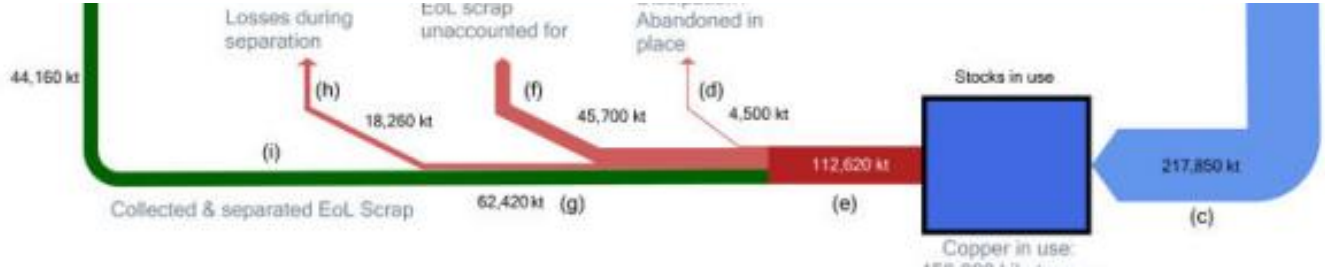


Materials recovery systems are inefficient

FIGURE 3: Global Copper Stocks and Flows 2009 – 2018 (ICA/Fraunhofer, 2020).

Smelting & refining / SXEW | Total refined copper | Semi-finished goods production

Total end of life	112,620 kt		
Abandoned	4500 kt	4.00%	
Landfill/Lost	45700 kt	40.58%	
Losses in materials recovery	18260 kt	16.21%	
	68460 kt		
	44,160	39.21% recovered	



PV Panels: Australia's Biggest Silver mine

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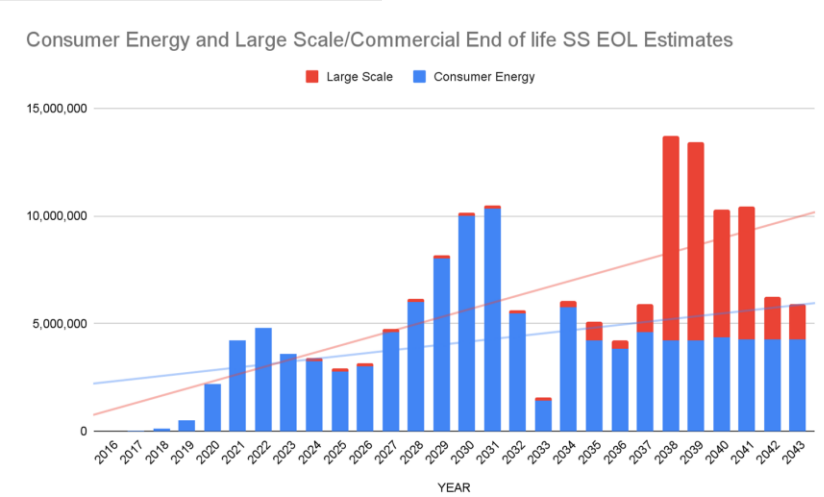


Market Estimates - 2043

Difficult to forecast

Estimated Recoverable Weight by Material (Metric Tonnes):

- **Glass:** 1,729,000 - 2,074,500
  - Based on 60-75% of module weight, with a 90% recovery rate.
- **Aluminum:** 273,000 - 409,500
  - Based on 10-15% of module weight, with a 95% recovery rate.
- **Copper:** 68,250 - 102,375
  - Based on 2.5-3.75% of module weight, with a 95% recovery rate.
- **Silicon:** 136,500 - 204,750
  - Based on 5-7.5% of module weight, with an 80% recovery rate.

National - End of life

145 Million modules - 134m Consu

A $6.5 Billion resource opportunity

Australia's Biggest Silver Mine
2.9 Billion Grams
AUD $4 Billion

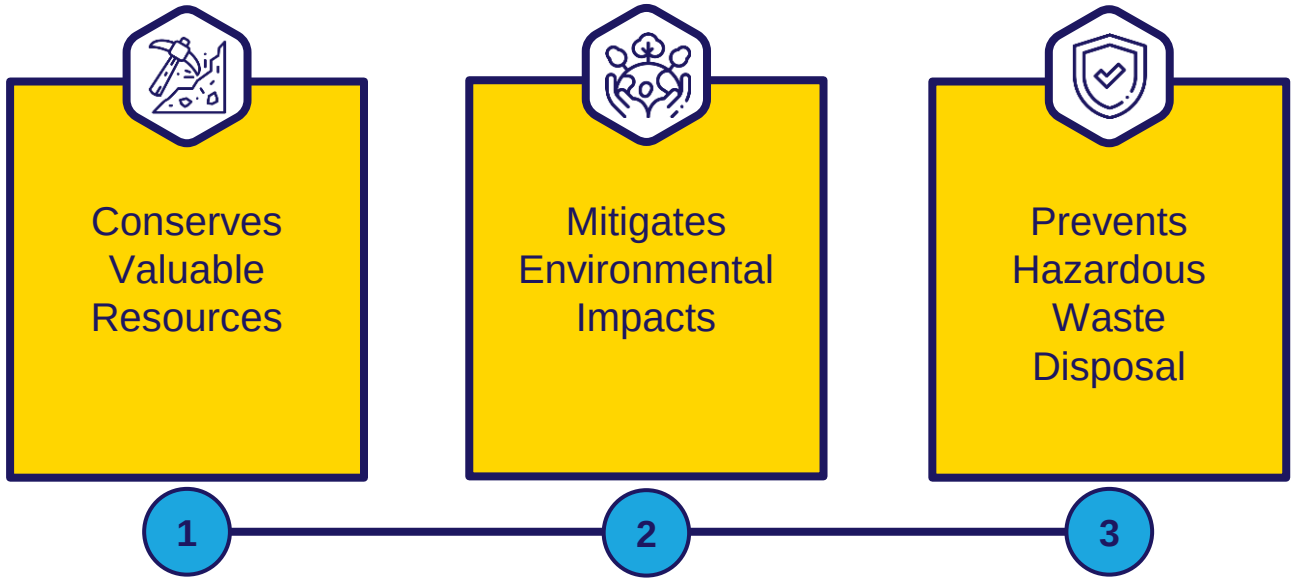
Massive Opportunity for Entrepreneurs

Dr Marina Lunardi

TECHNICALITIES

Solar module recycling: challenges and opportunities

Key Reasons for Recycling Solar Modules



Most Common Solar Module Technologies

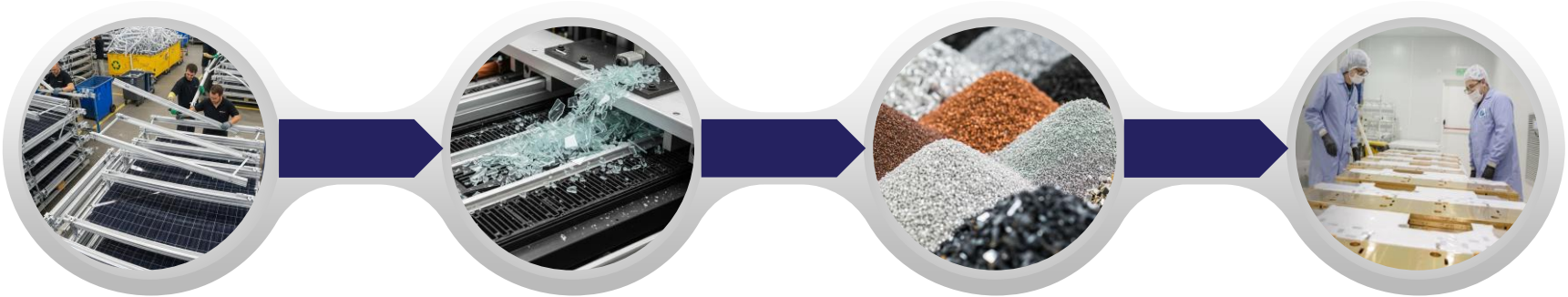
Silicon-based Modules: Market Leaders

Silicon solar modules dominate the market, offering high efficiency and longevity, making them the preferred choice for many applications.

Thin-film Modules: Flexible Alternatives

Thin-film solar modules are less common but present unique benefits, including flexibility and potentially lower production costs, allowing for diverse installation options.

Key Steps in Module Recycling



Frame and Junction Box removal

The panel’s aluminium frame and junction box are removed — both are easily recyclable.

Glass Separation

The glass layer is detached using **mechanical**, thermal, or chemical methods.

Cell & Material Recovery

Silicon cells, copper, silver, and other valuable metals are extracted for reuse or refining.

Material Reuse or Processing

Recovered materials are sent to manufacturers for reuse in new products.

The Use of Recovered Solar Materials

Aluminium

- Metal Manufacturing/Smelting
- Construction Industry
- Automotive Industry
- Packaging Industry

Glass

- Construction Industry
- Glass Manufacturing
- Abrasives

Silicon

- Electronics Industry
- Chemical Industry
- Metallurgical Industry

Silver

- Electronics Industry
- Jewellery Industry
- Investment/Bullion

Copper

- Metal Manufacturing/Smelting
- Electronics Industry
- Construction Industry

Other Valuable Metals (e.g., Lead, Cadmium):

- Specialised Refining/Smelting

What is next?

Standardisation of Solar Panel Designs

This will simplify disassembly and recycling. Uniform materials, sizes and components will streamline operations, boosting recovery rates and cutting costs.

Advancements in Recycling Technologies

Innovations will boost the recovery of more and higher-quality materials, while reducing energy consumption and increasing profitability.

Implementation of EPR* Programs

Making manufacturers responsible for EOL panel management, encourages them to design more recyclable products. This fosters innovation and creates a sustainable disposal system.

*Extended Producer Responsibility (EPR)

Solar Module Recycling Initiatives in Australia

Economic and Logistical Barriers

High costs often outweigh recovered material value, deterring investment. Also, the need for robust collection systems is essential to ensure that end-of-life modules are gathered and processed effectively.

Regulatory and Safety Challenges

A strong and consistent framework promotes best practices and sets recycling standards, ensuring safety and environmental protection. Without it, solar recycling efforts will be inconsistent, leading to more waste and missed resource recovery.

Robyn Cowie

PILOT DATA

Proof points & High Appetite - key learnings

Demand Exceeded All Expectations

Target: 20,000 - 30,000 panels

Collected: 23,587 panels

Collections closed early due to exponential growth in demand

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A Clear Picture: The Demand is Real & Diverse

A New Resource Stream

Material	Share	Recovered (kg)
Glass	75.0%	297,248
Aluminium	10.0%	40,884
Plastic*	5.0%	10,430
Silicon	2.5%	8,866
Copper	0.2%	594
Silver	0.003%	11

*Estimates only. Final report due September, 2025

A Mandate from Homes and Industry

1/3 of panels stored for over a year

103 unique solar installation companies participated

Large-scale challenges

*Warwick Solar Farm decommissioned panels

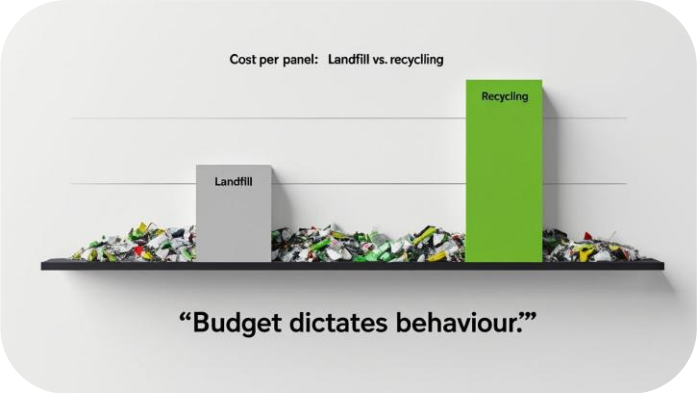
The "Slow Trickle": Prohibitive transport costs for small, regular breakages.

The "Repowering Wave": Lack of end-of-life plans for large-scale upgrades.

Our Response: Developing targeted guidance materials.

The Barrier and the Mandate

The Barrier is Cost



The Industry Mandate

A clear mandate for a National Scheme

From Pilot to Industry: The Queensland Success Story

John Hill from Pan Pacific Recycling showing Treasurer Jim Chalmers the critical mineral recovery process

We kick started a new industry

Before: 0 Now 3+

Alexander May, Technical Manager, Sircel Limited

Solar Panel Recycling trial

Turning e-waste into e-resources.

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Solar Panel Recycling Trial: project overview

Solar Panel Recycling at Sircel - video

Multi-site approach: Yatala, QLD

Broken panels triaged and processed at Yalata.

- Glass
- Copper
- Aluminium

Commodities generated used in local manufacturing.

Multi-site approach: Parkes, NSW

Unbroken panels processed at Parkes.

World-leading tech

1 panel / min.

Results: 99% material recovery rate

~3,000 kgs

99% recovery rate

1% landfill (PVC)

Circular Economy

- 18% aluminium
- 15% cell sheet
- 65% glass
- 2% copper & j-box

Learnings

logistics

sig. freight costs

broken panels

—

supported logistics solutions

processing

broken panels = lower yield

—

awareness campaign: ‘take care of old panels’

systemisation

inconsistent cataloguing of panels

—

digitised, central system tracking serial #s from install to recycling

manufacturing

limited local offtake buyers

—

local manufacturing needs govt. support

So What?

what we know	+	what we need
Technology is proven and scalable		Capital investment
Resource recovery rates are high		Govt. support and funding
Australia's largest e-waste recycler		Industry incentive structure, incl. installer rebates
Solving a small % of the problem		

Industry Needs

Nat. Scheme

Examples:

NTCRS

Germany

Accreditation

industry accreditation

third-party auditing + certifications

Q & A

QUICK POLL

Notices & Reminders

- POSTPONED Renewable Sector Stewardship Enablers - to 10.30am Tuesday 16 September
- NEXT WEBINAR in this series **Solar PV Reuse** is on Thursday 11 September
- Registration for both webinar is available online at https://smartenergy.org.au/reuse-recycle/

- Recording and Slides will be made available to webinar registrants.

THANK YOU

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