Sycamore
Sustainable Electronics Recycling

Electronic and Solar Panel Processing and Recycling

Steve Figgatt
Founder and CEO, Sycamore International Inc.
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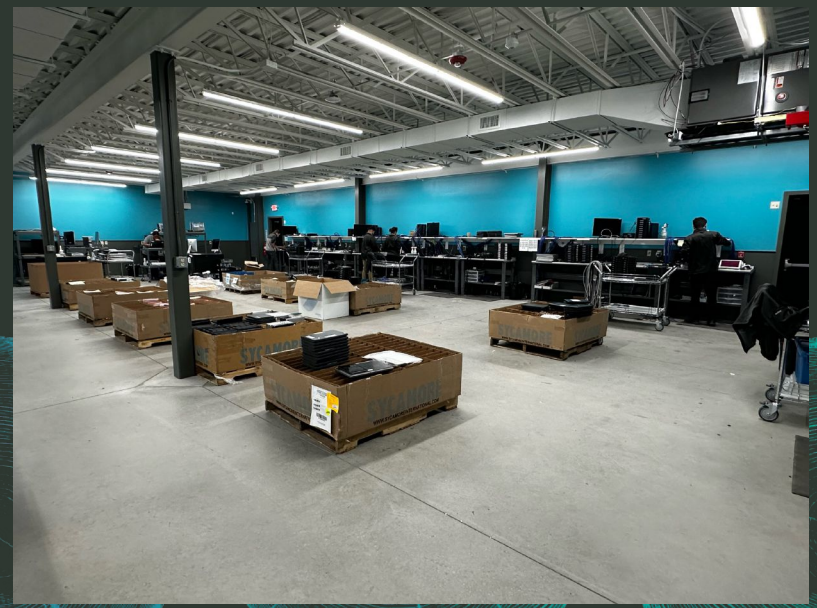
Sycamore, ITAD and the Circular Economy

Sycamore Background / Circular Economy / ITAD / Electronics Recycling Overview

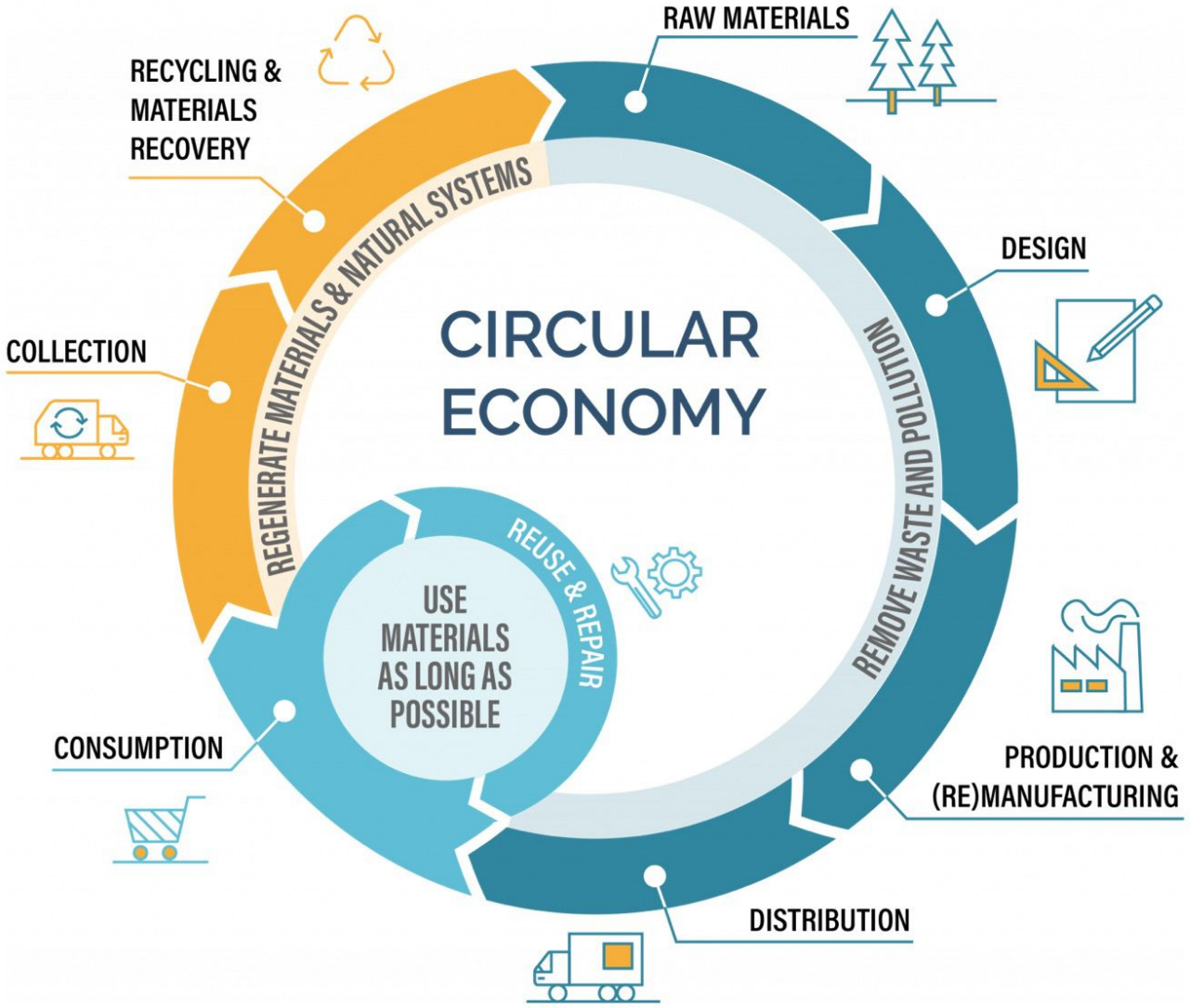
Sycamore Background

- Started in 2010. Operate a fleet of trucks from MA to VA, providing electronics recycling services to millions.
- Our core business model is designed to capture value from electronic waste streams by extending the life of viable equipment, share the ROI with our partners, while routing obsolete electronics into vetted responsible recycling material streams
- In 2025, we refurbish ~40,000 devices per month for reuse and process ~12 million lbs. of electronics for responsible recycling annually
- Downstream customers for refurbished electronics
- Inherent value in waste material streams

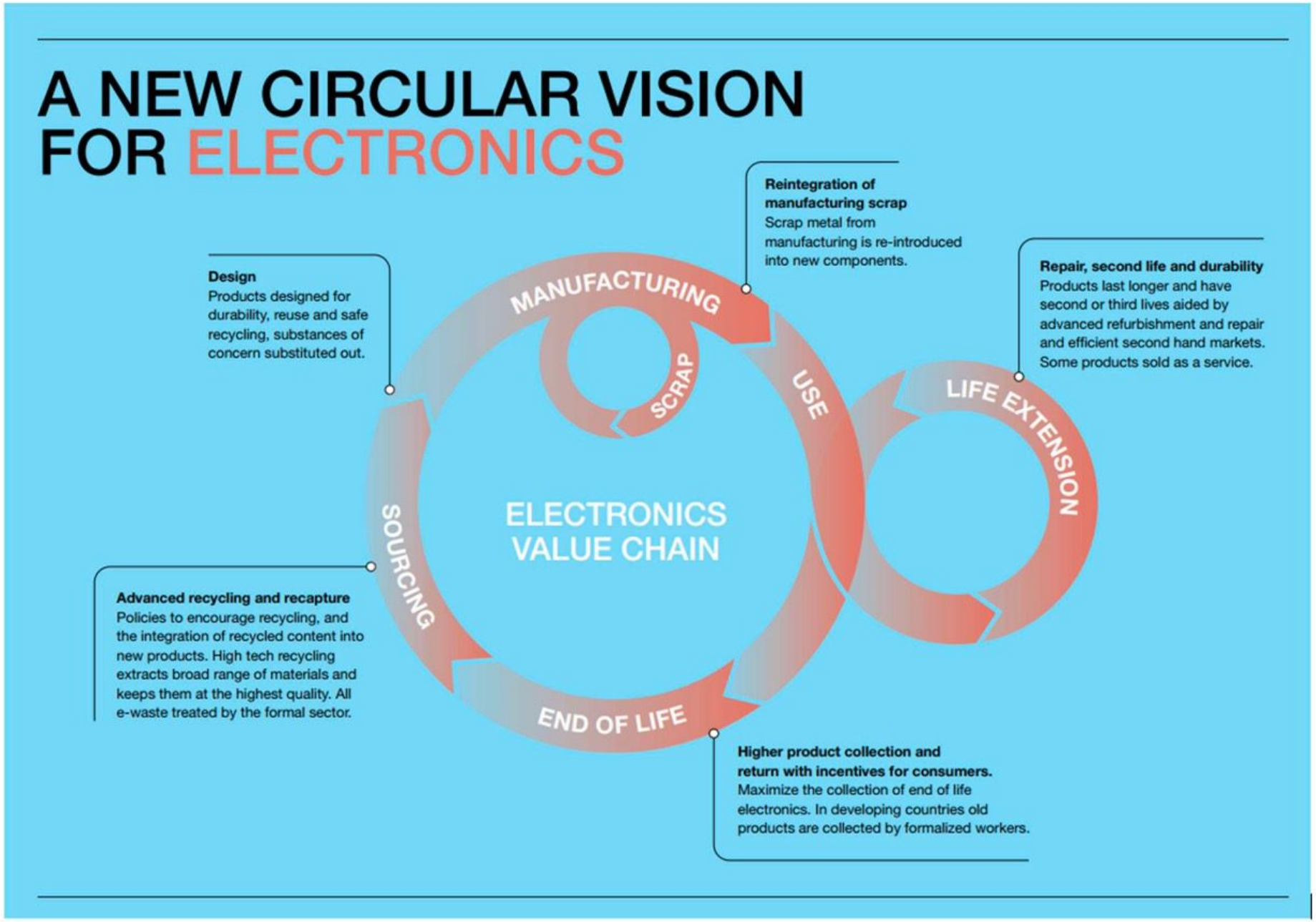


Circular Economy

- What is the Circular Economy?
  - Reimagining the old system as a continuous loop that transforms design, manufacturing and use of goods and materials
- What is the opportunity?
  - A prosperous economy
  - A vibrant and diverse environment
  - Ex. Steel (~92% recycled) and Aluminum (~65% recycled) material recovery



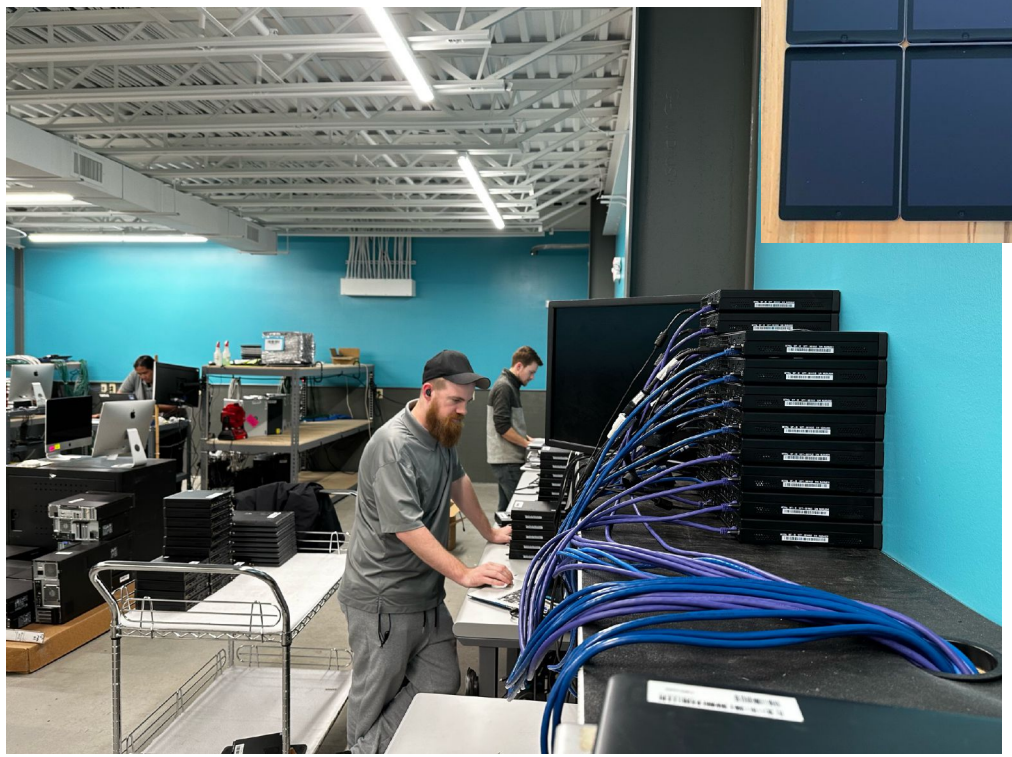
A NEW CIRCULAR VISION FOR ELECTRONICS



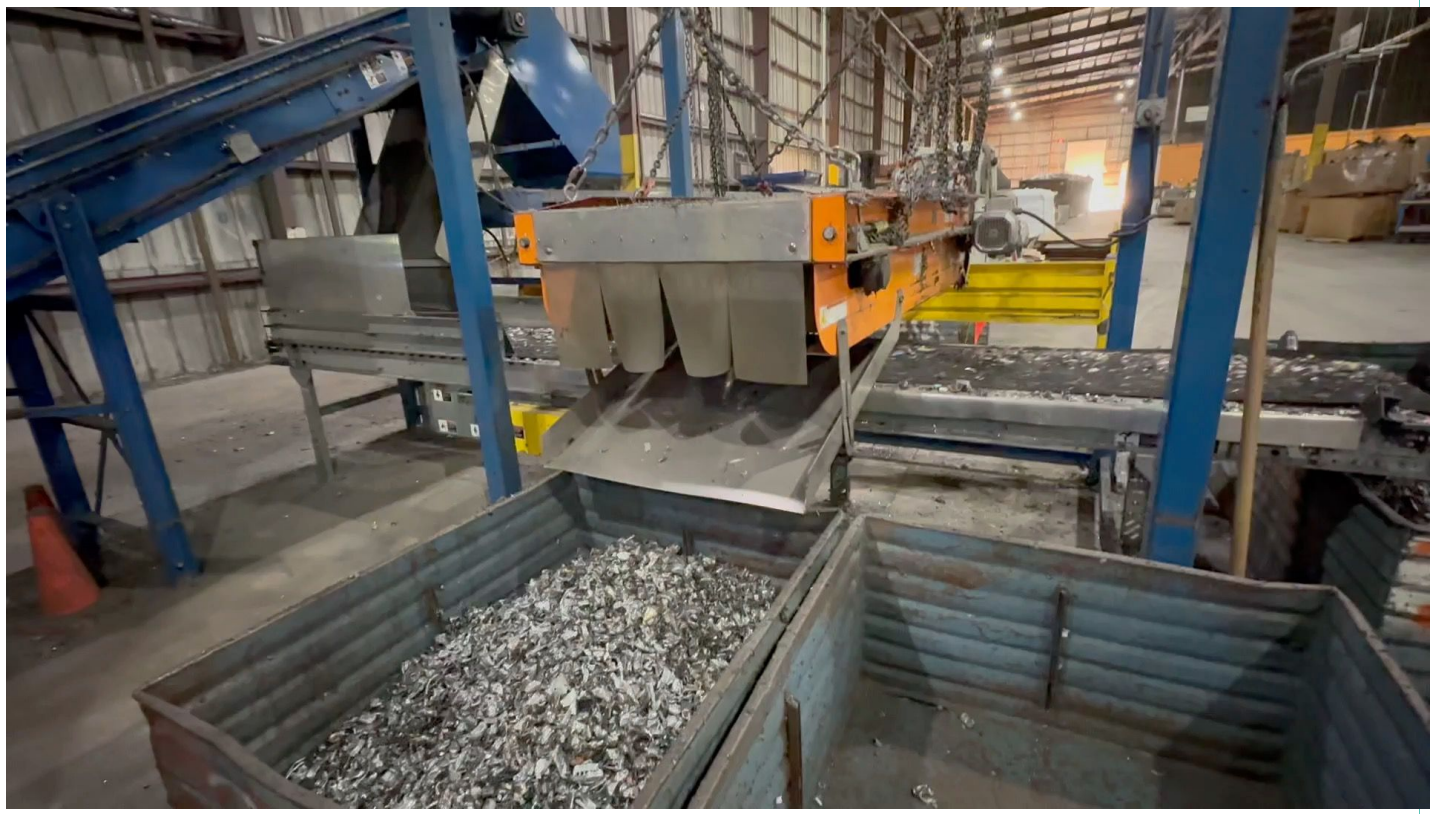
Source: World Economic Forum, A New Circular Vision for Electronics, 2019

ITAD and Electronics Recycling

- Information Technology Asset Disposition: Recapturing value



Electronics Recycling



ITAD Industry and Electronics Recycling

E-waste Challenges and Solutions / Reusing Materials In Waste Streams vs Virgin Materials / Reuse and Recycling Industry Standards / State Collection Programs

E-waste Challenges

- ~25% of E-waste is collected in the United States according to the EPA
- Cathode Ray Tubes (CRTs)
- Lithium-Ion Batteries
- Lead and Heavy Metal Contamination
- Complicated reverse logistics
- Fractured market
- Little Federal oversight

E-waste Challenges Cont.

- Challenge: CRT Processing
  - A growing challenge from 2005 - 2020
  - Leaded glass
  - Illegal export and dumping in developing countries
  - Industry bankruptcies
  - Environmental Cleanup

Source: Smithsonian Magazine, 2019

E-waste Challenges Cont.

Timeline: The collapse of a colossal CRT downstream

Published: January 19, 2023
Updated: January 31, 2023
by Jared Paben

Photo illustration by Tori Maier-Mahaffy with photos from EnSafe and Resource Recycling, Inc.

Over several years, Closed Loop Refining and Recovery was paid to take hundreds of millions of pounds of cathode-ray tube (CRT) materials at sites in Phoenix and Columbus, Ohio. In 2016, the company collapsed, leaving behind massive, contaminated sites that others have had to pay to clean up.

The aftermath provides a cautionary tale for the electronics recycling industry: Be careful where you ship your toxic residuals because the decisions could haunt you for a long time. Years after Closed Loop failed, nearly 100 electronics recycling companies, OEMs and others have been sued over shipments of CRT materials, resulting in settlements totaling millions of dollars.

The cleanups themselves have stretched on for seven years with most of the leaded glass ultimately ending up in landfills.

Source: E-Scrap News January 2023

- Closed Loop Refining Debacle
- Over 100 million pounds of partially processed and hazardous leaded CRT glass was left behind after the bankruptcy of Closed Loop Refining and Recovery. The burden to clean up impacted hundreds of companies, local and state governments.
- The waste ultimately wound up mostly in landfills

E-waste Challenges Cont.

Why Recycling Plants Keep Catching on Fire

Firefighters pour water on an industrial fire in Richmond, Ind., on April 13, 2023. Michael Conroy—AP

Toxic smoke is spewing from an inferno at a recycling plant known as a 'fire hazard,' officials say. The flames could burn for days

By Omar Jimenez, Bonney Kapp, Sara Smart, Brenda Goodman, Michelle Krupa and Holly Yan, CNN
Updated 12:07 AM EDT, Thu April 13, 2023

- Lithium battery processing and exothermic reactions
- Safe dismantling training, procedures and responsible recycling amidst declining average device asset values

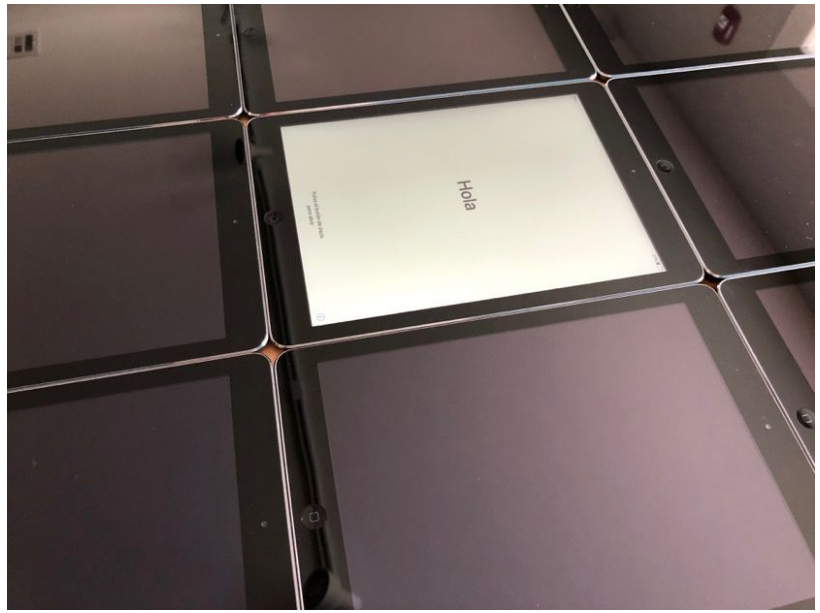
Andrey Deryabin via Getty Images

Opportunities

- Li-Cycle raises $375 million for Rochester, NY plant expansion.
- Hydrometallurgical Processing – high yield lithium material recovery
- Redwood Materials raises over $2 billion in the last 24 months.
- Rare earth mineral recovery
- Solar panel recycling

REDWOOD MATERIALS

Li-Cycle



Developing Industry Standards

vs

- Two competing standards developed: R2 and e-Stewards
- SERI (Sustainable Electronics Recycling International) and R2 Standard: Reuse. Recycle.
- R2: 2008, R2: 2013 and the new R2v3 Standard
- End of Life Cybersecurity/Consumer Data Protection

Certifications Summary

R2 (Reuse and Recycling)

- R2 is a voluntary global standard that prioritizes a hierarchy of reuse before recycling and is a comprehensive, outcomes-oriented standard that includes best practices for protecting the environment, the health and safety of workers and communities, and data while complying with all applicable legal requirements and providing accountability through the entire processing of your equipment.
- **R2 is Comprehensive**: R2 isn't just a data security standard, or an environmental standard, or a worker health and safety standard. R2 is an electronics sustainability standard, which means it is a data security standard AND an environmental standard AND a standard that protects worker health and safety, all in one. That means when you choose an R2 Certified Facility like ours, you are checking many boxes in your vendor selection process all at once.
- R2 sets the standard for responsible reuse and recycling practices, including data security, environmental protection, resource preservation, and the health and safety of workers. We're proudly an R2-Certified facility, which means we're held to that higher standard for how we handle your used electronics, including independent audits as part of the process. And that's how you can be confident that your brand is protected when entrusting your electronics to us.

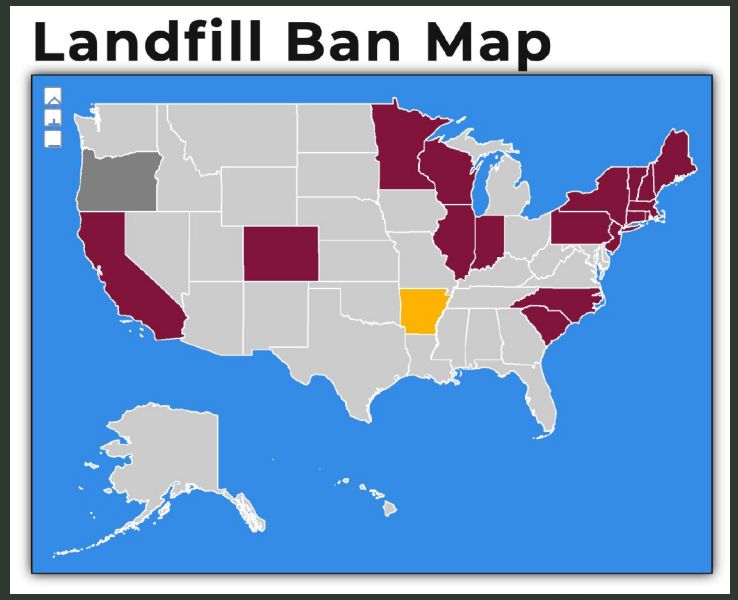
NAID (National Association of Information Destruction)

- **Audit Quality**: All NAID AAA Certified service providers are subject to regularly scheduled, onsite audits by trained, accredited security professionals. In addition, random, unannounced audits are structured so NAID AAA Certified operators will not know when they will be audited next.
- **Regulatory Alignment**: The program requires written policies and procedures to ensure incident response preparedness, employee training, and regulatory compliance.
- **Security Specifications**: Accredited auditors review employee background screening and training, compliance with written procedures, access controls, operational security, destruction equipment, and confidentiality agreements.
- **Oversight**: The Certification Review Board and the Certification Rules committee oversee the program's integrity, both of which contain industry veterans and outside, accredited professionals.

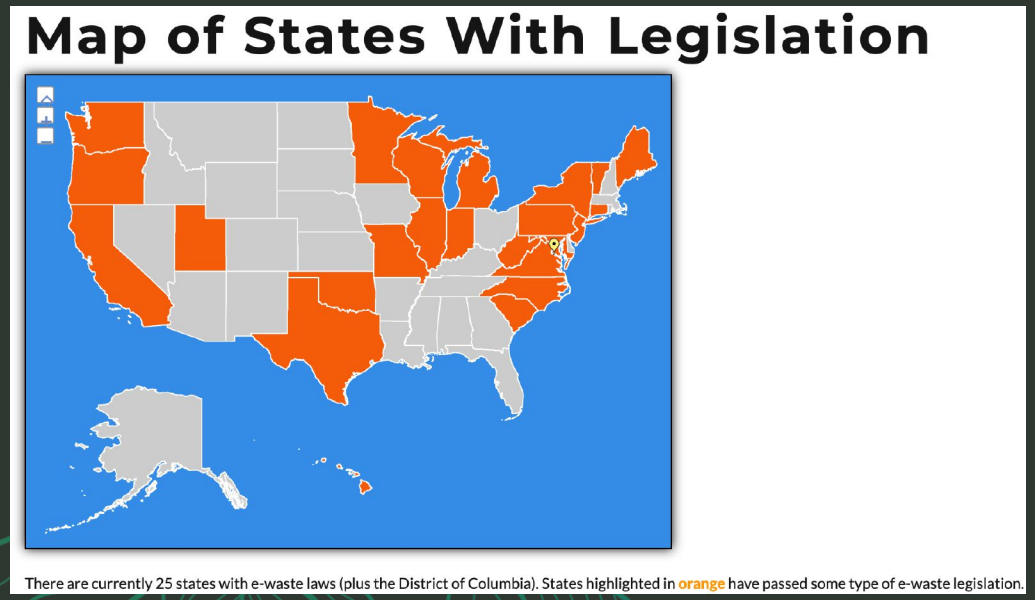
Reuse and Recycling Industry

- **State Collection Programs vary by model:**
  - **Electronic Producer Responsibility (EPR)**
    - **Market Share EPR** – (ex. New Jersey and New York) - Allocates manufacturer obligations directly in proportion to the manufacturer's market share or sales volume.
    - **Clearinghouse EPR** – (ex. Virginia and Maryland) The collection and recycling is managed by centralized third parties, such as county governments or retail operations

  - **Individual Producer Responsibility** – Mandates that each waste stream producer must directly manage the collection and recycling of their own products.
  - **Hybrid Models** – Some electronics disposal programs also introduce recycling fees at the point of sale, requiring consumers to pay when purchasing a new product. Fees are typically centralized within an administrating agency and used to offset disposal costs as part of larger collection and recycling programs. (Ex: California)



Source: Electronics Recycling Coordination Clearinghouse

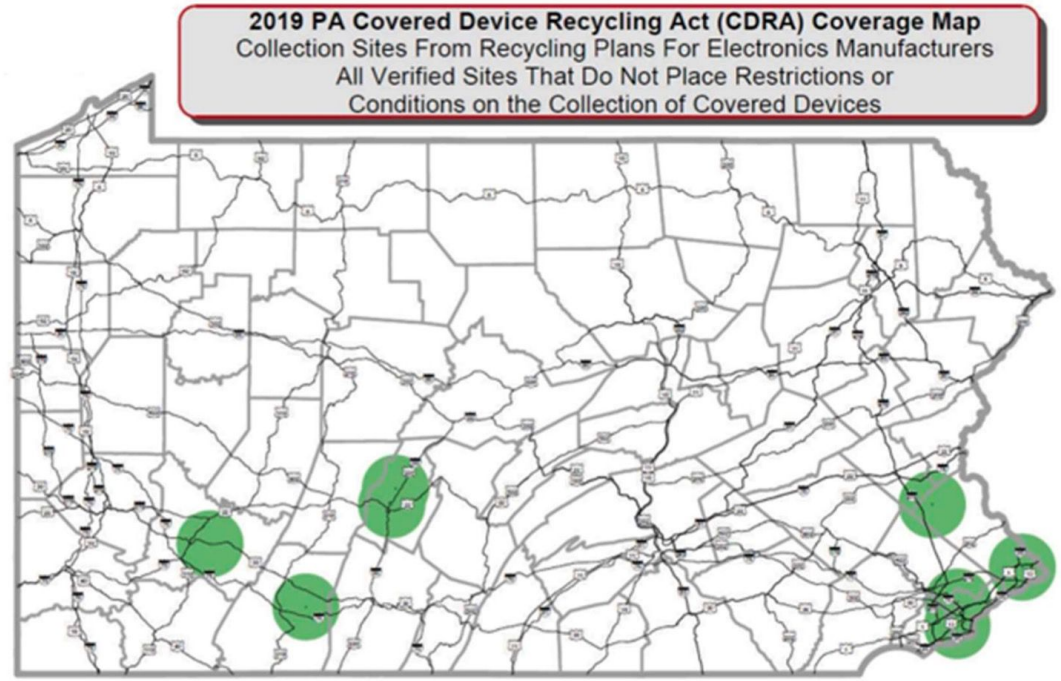


Source: Electronics Recycling Coordination Clearinghouse

Covered Device Recycling Act (CDRA)

- The Covered Device Recycling Act was signed into law in 2010.
  - Established a manufacturer-funded electronics recycling landscape in PA
  - Covered Devices included devices used by consumers at the time
  - “Covered Device” definitions are too narrow to capture ever-changing forms of technology products
  - According to the DEP, only 23.7% of Pennsylvanians currently have access to electronics recycling
- Opportunity: expand the definitions for covered devices to include relevant electronics in 2025 and beyond, data bearing products, while considering expansion of covered entities/consumers to enable market driven solutions as seen in other states

Figure 1: Where is taxpayer access to e-waste recycling in Pennsylvania?



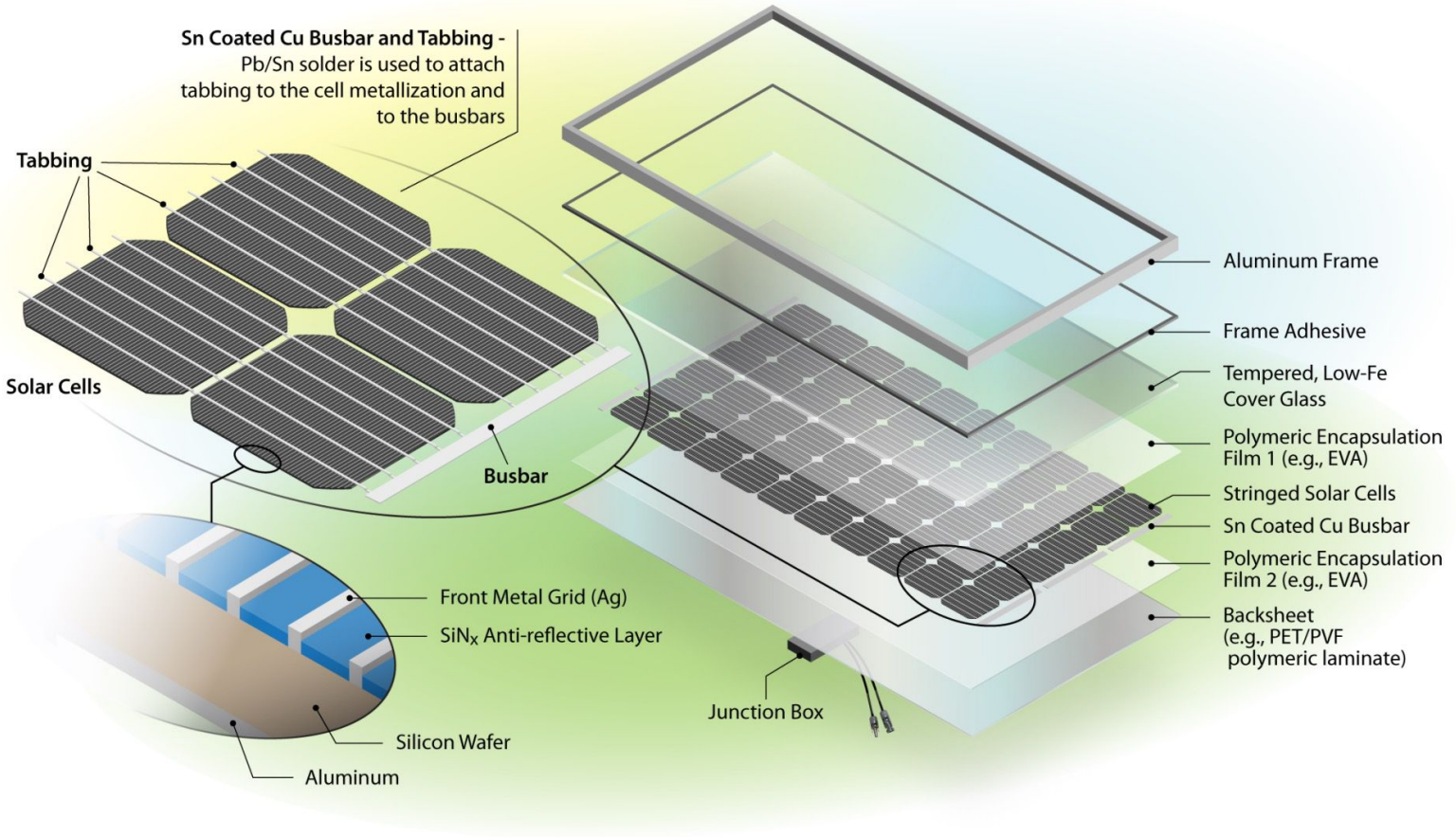
Source: PA Department of Environmental Protection Report to the General Assembly, 2020

Solar Panel Recycling

Photovoltaic Module Composition / Cost Reduction of Photovoltaics Over Time / Solar Panel Recycling Economics 2025 / Closing Q&A

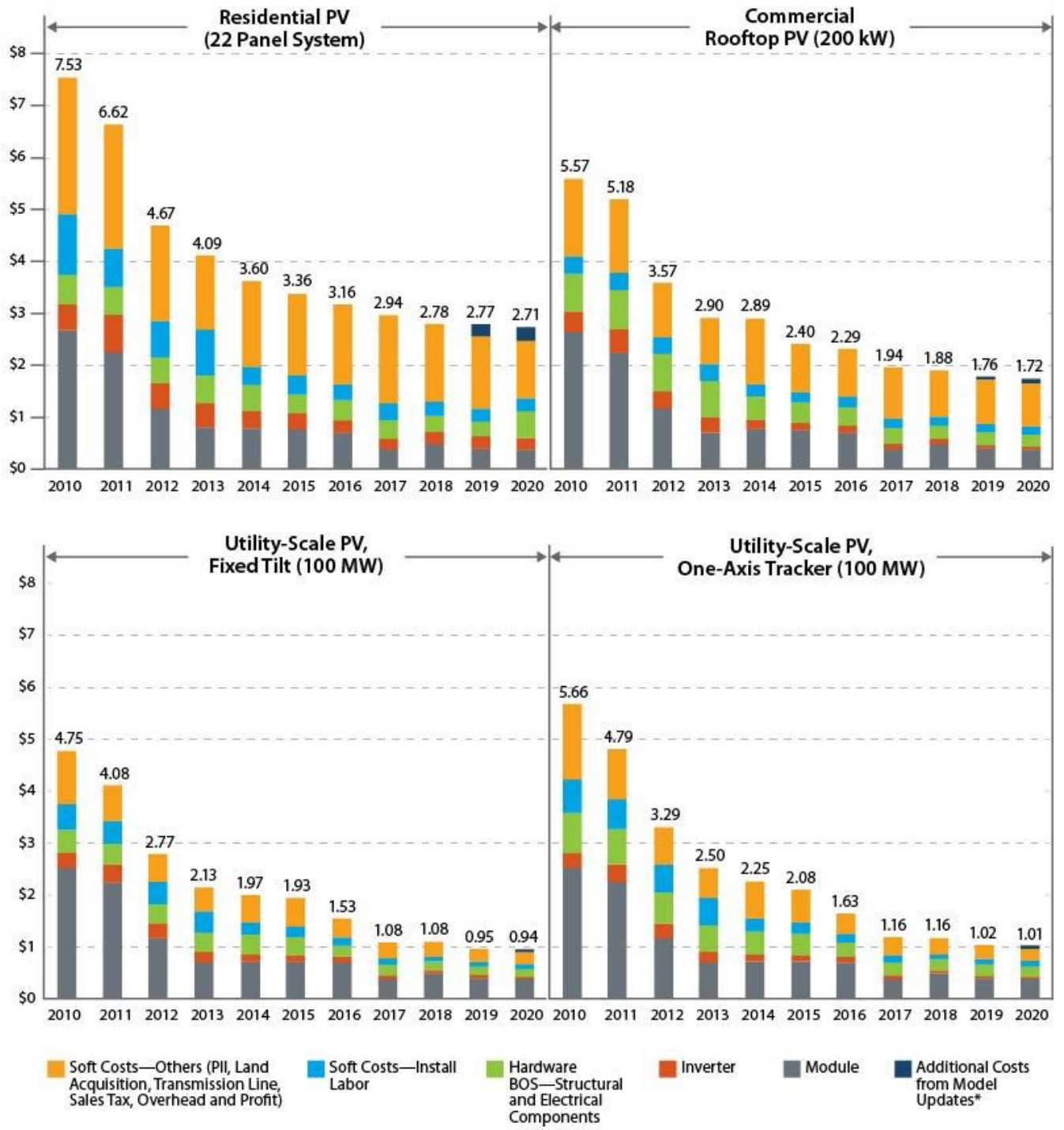
PV/Solar Panel Recycling

- **Types of Common Photovoltaic Modules:**
  Monocrystalline silicon, Polycrystalline silicon, Roof tiles, Thin Film



Source: NREL + US EPA
https://www.epa.gov/hw/solar-panel-recycling

Cost Reduction of photovoltaics over Time



Source: NREL (National Renewable Energy Laboratory)

Solar Panel Recycling Economics in 2025

- PV Panels are composed of Aluminum (6063 Al), low iron solar glass, silicon, copper, silver, polymers, polyethylene terephthalate (PET)
- Inherent value of materials ~$10 - $14/panel
- Cost to process, separate and recycle ~$0.30 - $0.50/lb ($13 - $25/panel)
- Cost to landfill: $0.04 - $0.05/lb (~$2 - $4/panel)
- After 20 years, most PV panels will still produce ~80-90% of originally rated power output, depending on the manufacturer
- Value of tested/refurbished secondary panels and developing markets

Materials Recycled and Energy Recovered By the treatment of 1,000 kg of PV Waste		
Material	kg	lb
Aluminum (Usually 6063 Al alloy)	182.65	402.67
Low iron solar glass	700	1543.23
Copper from cable and junction box	3.3	7.28
Copper from Connectors	1.14	2.51
Silicon metal - solar cell	36.5	80.47
Silver (Ag)	0.53	1.17
PV encapsulation and non-fluorine back sheet layer	66	145.50
Polymer from copper cable encapsulation	6.7	14.77
PV encapsulation and non-fluorine back sheet layer	66	145.50

Closing

Questions & Answers