ecotone

SERI: R2 Certification Long-Term Outcome Analysis

Technical Documentation

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Logic Model

About this Report:

Ecotone Analytics conducted this impact analysis to assess and project the social, health, and environmental benefits associated with SERI's R2 Certification. R2 certified facilities help prevent environmental contamination and protect worker health by diverting used electronics from unsafe processing. By enforcing strict safety standards, they reduce exposure to hazardous substances, addressing both environmental and occupational health risks.

About Ecotone Analytics:

Ecotone Analytics is an impact analysis, strategy, and communications organization for clients' social and environmental impacts. Combining evidence-based research analysis and monetization of impact outcomes, Ecotone derives client-specific valuations and identifies the key stakeholder groups to whom those impacts accrue.

Disclaimer: This assessment addresses the impact measurement and management systems, practices, and metrics employed by the impact assessment consultants. It does not address financial performance and is not a recommendation to invest. Each investor must evaluate whether a contemplated investment meets the investor's specific goals and risk tolerance. Ecotone Analytics GBC (Ecotone), its staff, and Ecotone analysts are not liable for any decisions made by any recipient of this assessment.

This assessment relies on the written and oral information provided by the analyst at the time of the Ecotone analysis. Under no circumstances will Ecotone, its staff, or the Ecotone analysts have any liability to any person or entity for any loss of damage in whole or in part caused by, resulting from, or relating to any error (negligent or otherwise) or other circumstances related to this assessment.

Outcome Estimation Considerations

Outcomes are Estimations: The analysis pairs R2 facility data with external literature to estimate what the impacts could be. This is not a measurement of actual achieved impact.

Conservative Approach: The analysis adopts a conservative approach to ensure that impacts are not overstated. The actual benefits generated may vary based on individual facilities, their role in the value chain, and the existence of other R2 facilities in their value chain.

Non-Monetized Outcomes: While the analysis focuses on estimating the quantified value and as feasible, monetary value, of outcomes, there are certain benefits that are not quantified due to lack of evidence but may still hold significant value.

Data Limitations: Gaps in data availability and the evidence base limit the scope of the analysis. It is rare for a study to isolate the effects of certification alone, making it so there were few data points to use to inform impact projections. Addressing these gaps in future research could refine outcome estimates and add to the value currently estimated.

Outcome Estimation Counterfactuals

To estimate the value added by R2 certification, the analysis relied on two primary counterfactual scenarios:

Formal but uncertified facilities – These represent operations that meet basic legal and infrastructural standards but have not achieved R2 certification. This scenario isolates the benefits that result directly from certification, including improved data security, environmental management, and worker safety practices. This is SERI's preferred counterfactual, although evidence for this comparison is often limited.

Informal processing – In contexts where informal handling of used electronics is widespread, certification plays a role in shifting market share toward safer and more accountable operations. R2 certified facilities reduce the likelihood that used electronics are handled by unregulated actors at any point in the value chain. While the overall volume of electronics processed informally may remain high due to global used electronics waste growth, R2 facilities help divert significant quantities from landfilling or uncontrolled disposal, particularly in lower-income country contexts.

Note: While these scenarios provide structured points of comparison, the actual used electronics value chain is often more complex, blending both formal and informal stages (e.g., informal collection feeding into formal recycling).

This dual-counterfactual framing allowed the analysis to better attribute impact to certification, while acknowledging the limitations and evolving dynamics of global used electronics management systems.

Data Findings

A. Volumes and devices processed

B. Global workforce

C. Affordable access to low-income communities

D. Drop-off collection points

E. Collection events

Data Findings

This section presents key findings derived from internal data provided by SERI, offering insights into some of the operational outcomes associated with R2 certified facilities. The analysis draws on the most recent data collected through a survey to all R2 facilities during 2025, relating to facilities' 2024 operations.

Of note, not every R2 facility responded to the survey. Overall, 21% of facilities did not respond. As a result, the following figures are not the total for all R2 facilities, but only for those who responded.

Volumes of Devices Processed

SERI's R2 certification program promotes responsible management of used electronics through three core pathways: testing and repair, reuse, and recycling. The tables provide a detailed breakdown of **the top 10 categories** of devices processed by R2 certified facilities in 2024 across these pathways, disaggregated by region.

The first table reports test and repair outflow, measured in weight (kilograms), highlighting large volumes of professional IT equipment, laptops, and small electronics being restored for potential reuse—particularly in North America. The second table presents reuse figures in unit counts, showing the global circulation of devices such as mobile phones, laptops, and consumer electronics that have been refurbished and returned to the market. North America and Asia lead in these activities, with Europe also contributing significantly. The third table covers recycling volumes, also measured in kilograms, showing the recovery of valuable materials such as ferrous and non-ferrous metals, plastics, and glass. Again, North America processes the largest volumes, followed by Asia.

Table 3. Outgoing volume of devices (in KG) for testing and repair – Top 10 Devices

TEST & REPAIR								
Type of device	Africa	Asia	Europe	North America	Oceania	South America	#N/A	Grand Total
Professional IT equip WT	[redacted]	538	-	1,952,569	-	-	[redacted]	[redacted]
Harvested comp electr WT	[redacted]	8,863	-	591,857	-	-	[redacted]	[redacted]
Desktop PCs WT	[redacted]	22,680	-	343,894	-	-	[redacted]	[redacted]
Oth whole electr not WT	[redacted]	967	-	277,684	-	-	[redacted]	[redacted]
Small IT equipment WT	[redacted]	6,152	-	216,294	-	-	[redacted]	[redacted]
Mxd flat-panel displ WT	[redacted]	-	-	172,526	-	-	[redacted]	[redacted]
Laptops WT	[redacted]	19,316	-	144,424	-	-	[redacted]	[redacted]
Small Consumer Electr WT	[redacted]	-	-	79,803	-	-	[redacted]	[redacted]
Oth telecom equip WT	[redacted]	-	-	48,569	-	-	[redacted]	[redacted]
Mobile Phones WT	[redacted]	-	-	45,110	-	-	[redacted]	[redacted]

Note: Unit of measure is kg.

Regional data was redacted for confidentiality purposes.

Table 4. Outgoing quantity of devices (in units) for reuse – Top 10 Devices

REUSE							
Type of device	Africa	Asia	Europe	North America	Oceania	South America	#N/A
Mobile Phones UNIT	[redacted]	4,791,309	87,075	39,297,023	42,893	3,702	339,643
Harvested Comp of elecr UNIT	[redacted]	10,283,145	2,425,152	14,430,954	106,085	31,660	613
Laptops UNIT	[redacted]	1,561,049	1,198,784	9,329,396	505,188	92,453	31,368
Small IT equipment UNIT	[redacted]	854,010	652,964	7,901,508	136,490	23,040	9,256
Small Consumer Electronic UNIT	[redacted]	17,145	22,322	6,958,406	72,370	6,540	5
Other telecomm equ UNIT	[redacted]	215,639	8,804	4,765,599	16,509	1,867	227
Oth whole electr not list UNIT	[redacted]	1,785,218	406,116	1,505,312	-	1,131	5,448
Desktop PCs UNIT	[redacted]	280,100	224,598	2,648,634	210,433	43,786	8,195
Professional IT equip UNIT	[redacted]	540,102	307,895	1,274,909	70,357	20,421	3,463
Flat-Panel Display Monitor UNIT	[redacted]	166,428	119,919	770,602	163,776	83,125	2,291

Note: Unit of measure is units of devices.

Africa data was redacted for confidentiality purposes due to low numbers of facilities in the region.

Table 5. Outgoing volume of commodities/devices (in KG) for recycling - Top 10

RECYCLE							
Type of device	Africa	Asia	Europe	North America	Oceania	South America	#N/A
Comm/scrap: Ferrous WT	[redacted]	47,777,699	5,431,110	84,121,826	3,756,189	2,137,292	-
Commod/scrap: Plastics WT	[redacted]	13,945,682	1,565,614	43,548,207	211,135	508,183	2,190
Comm/scrap: Metals-oth WT	[redacted]	8,825,086	637,151	40,227,634	6,963	189,207	9
Commodities/scrap: Oth WT	[redacted]	20,634,120	2,552,683	22,364,195	164,080	1,379,736	-
Com/scrap:PrintCircBrd WT	[redacted]	6,186,177	200,370	30,294,333	-	147,412	-
Comm/scrap: Batteries WT	[redacted]	4,878,319	402,674	15,282,153	46,561	2,006,321	1,307
Flat-Panel Display Mon WT	[redacted]	458,132	255,289	20,843,333	6,051	47,700	34,521
Commodities/scrap:Alum WT	[redacted]	6,693,467	1,766,403	11,004,933	92,233	120,788	-
Comm/scrap: CRT glass WT	[redacted]	-	-	9,103,264	-	5,870,210	-
Comm/scrap: Copper WT	[redacted]	2,965,733	278,127	8,522,372	142,470	77,639	-

Note: Unit of measure is kg.

Africa data was redacted for confidentiality purposes due to low numbers of facilities in the region.

Total Greenhouse Gas emissions and social costs of carbon avoided from reuse and recycling at R2 facilities in 2024

Table 17.

	Estimated CO2e saved in 2024 for all reporting R2 facilities from reuse of devices		
	Kg CO2e saved from reuse, per device	Total Kg CO2e saved from all reused devices by R2 facilities	$ saved from all reused devices by R2 facilities
Mobile Phones	40	1,782,466,320	$258,457,616
Laptops	200	2,544,196,200	$368,908,449
Flat-Panel Display Monitor (24")	98	128,044,840	$18,566,502

Table 18.

	Estimated CO2e saved in 2024 for all reporting R2 facilities from recycling of devices		
	Kg CO2e saved from recycling, per device	Total Kg CO2e saved from all recycled devices by R2 facilities	$ saved from all recycled devices by R2 facilities
Mobile Phones	0.24	2,092,239	$303,375
Laptops	1.90	3,417,946	$495,602
Flat-Panel Display Monitor (24")	5.50	8,134,660	$1,179,526
CRTs (15-23 kg set)	19.00	1,717,323	$249,012

5.2. Global Workforce

The table below presents the estimated number of employees working at R2 certified facilities across different global regions. As of the latest data, the total workforce employed by R2 facilities exceeds 146,000 people. The majority of employees are based in Asia, accounting for over 124,000 workers, followed by North America with nearly 20,000. Other regions, including Europe, Oceania, Africa, and South America, host smaller but still significant numbers of employees.

Table 6. Number of R2 facilities' employees per region

	# of R2 facilities' employees
Africa	[redacted]
Asia	124,221
Europe	1,217
North America	19,868
Oceania	[redacted]
South America	[redacted]
Grand Total	**146,258**

Regional data was redacted for confidentiality purposes.

Of particular interest is the question related to the percentage of people employed by R2 facilities that come from communities that experience barriers to work (adults with disabilities, previous incarcerations, etc.). However, it appears that several respondents may have misunderstood the question and instead of providing percentages as requested, many seem to have reported absolute numbers of individuals (see table xx in the appendix). This limits comparability across facilities and suggests that clearer guidance or formatting (e.g., requiring a percentage input) may be needed in future data collection efforts to improve consistency.

5.3 Affordable Access to Low-Income Communities

R2 Facilities' donation programs aim to extend the life of used electronics while supporting digital inclusion efforts, particularly in underserved communities. Through R2 certified facilities, devices are either donated directly or sold at reduced prices to individuals and organizations with limited resources. The table below presents the number of devices donated and sold at a discount to low-income communities, disaggregated by region. North America stands out with the largest contribution—over 14,000 devices donated and nearly 25,000 sold at discounted rates. Asia and Europe also show significant engagement, with each region contributing over 1,000 discounted devices alongside hundreds of donations. In contrast, Africa, Oceania, and South America report smaller donation volumes and no discounted sales. In total, R2 facilities reported donating 16,462 devices and selling 27,064 devices at reduced prices, underscoring the global social impact of the R2 certification.

Table 7. R2 facilities' donations per region

	# of devices donated to low-income communities	# of devices sold at a discount rate to low-income communities
Africa	[redacted]	[redacted]
Asia	867	1,145
Europe	733	1,106
North America	14,113	24,796
Oceania	[redacted]	[redacted]
South America	[redacted]	[redacted]
Grand Total	**16,283**	**27,047**

Regional data was redacted for confidentiality purposes.

5.4 Drop-off Collection Points

The table below summarizes facility responses to the questions related to the number of permanent public drop-off locations they operate and the total weight of electronics collected through these free drop-off points. In total, 2,348 drop-off locations were reported across participating regions. North America accounts for the vast majority, with 1,957 locations and more than 8.6 million kilograms of collected electronics. Asia and South America followed with 158 and locations, respectively, while other regions reported minimal or no activity.

Table 8. Number of collection points and weight collected

Regions	# of drop-off locations	Drop-off Weight collected
Africa	[redacted]	[redacted]
Asia	158	102,759
Europe	1	0
North America	1,957	8,677,674
Oceania	[redacted]	[redacted]
South America	[redacted]	[redacted]
Grand Total	**2,347**	**8,864,213**

Note: Weight is measured in kg.

Regional data was redacted for confidentiality purposes.

5.5 Collection Events

The table below summarizes responses to questions about community collection events organized by R2 certified facilities and the weight of electronics collected. In total, 3,445 events were held, collecting approximately 4.17 million pounds of electronic waste. Asia hosted the most events (2,626), while North America collected the highest volume (2.79 million pounds) from 792 events. South America reported events and over pounds collected. Europe, Africa, and Oceania had minimal or no reported activity.

Table 9. Number of collection events and weight collected

Row Labels	# of Collection Events	Collection Events Weight
Africa	[redacted]	[redacted]
Asia	2,626	1,225,150
Europe	1	50
North America	792	2,791,576
Oceania	[redacted]	[redacted]
South America	[redacted]	[redacted]
Grand Total	**3445**	**4169429**

Note: Weight is measured in kg.

Regional data was redacted for confidentiality purposes.

Appendices

Executive Summary

SERI is committed to advancing safe, sustainable electronics reuse and recycling through implementation of its R2 Certification—the leading global standard for responsible electronics processing. The R2 Standard is designed to promote a circular economy, protect human and environmental health, and ensure ethical data management and reuse practices. As part of its broader mission, SERI commissioned this impact analysis to better understand the outcomes achieved by R2 Certified facilities and the value created for stakeholders around the world.

Ecotone Analytics conducted a social, environmental, and economic impact analysis based on primary and secondary data from facilities certified under the R2 Standard. The analysis assessed the net benefits generated through key areas of impact including responsible material recovery, health and safety for workers, data security, pollution prevention, and digital inclusion.

The findings highlight that R2 Certified facilities generate substantial impact above industry baseline practices. The table on the next slide highlights a sampling of prominent outcomes projected.

Introduction

Sustainable Electronics Recycling International (SERI) is a non-profit organization dedicated to advancing the responsible reuse, repair, and recycling of electronic products. Through the development and oversight of the R2 certification, SERI sets the global benchmark for sustainable electronics processing—protecting human health and the environment while promoting the circular economy.

R2 certified facilities span over 40 countries and handle a broad spectrum of used electronics, ranging from personal devices to large-scale IT equipment. As part of its commitment to transparency and continuous improvement, SERI is investing in better understanding and quantifying the environmental, social, and economic impacts of R2 implementation worldwide.

This analysis focused on the impact generated through four core value drivers embedded within the R2 standard:

Environmental Protection: R2 certified facilities must manage used electronics in ways that prevent environmental contamination. This includes the proper handling of hazardous substances, implementation of downstream due diligence, and processes that divert electronics from landfills or illegal export.

Worker Health and Safety: The R2 certification requires facilities to establish rigorous health and safety management systems to reduce risks from chemical exposure, and improper handling of hazardous used electronics materials.

Data Security and Consumer Protection: R2 certified facilities ensure that all data-bearing devices are properly sanitized, thereby preventing data breaches, identity theft, and other digital security risks.

Digital Equity through Reuse: By enabling the testing, repair, and resale of electronic devices, R2 facilities extend product life and improve access to affordable technology in underserved communities.

These practices stand in contrast to informal or uncertified electronics processing, which is often associated with significant risks to workers, the environment, and communities. The R2 certification provides a verified and structured approach to managing those risks while unlocking new avenues for sustainable economic value.

Logic Model

Stakeholders

The initial step in developing the analysis involved identifying stakeholders, determining the extent to which they are direct or indirect beneficiaries, and, in some cases, assessing any unintended negative impacts they might experience as a result of the program model. Table 2 outlines the key stakeholders involved.

This stakeholder identification provides a qualitative understanding of how different groups may be affected by, or contribute to, the R2 certification program. As shown in Table 2, a wide range of stakeholders may be affected by SERI's efforts.

Table 2. R2 certification stakeholders

Direct stakeholders	Indirect stakeholders
SERI team	Non-R2 certified facilities
R2 facility owners	Other used electronics industry workers
Workers in R2 certified facilities	Neighboring communities – local to original production and local to landfills/ used electronics disposal sites
R2 certified facilities' suppliers	Local and national governments
R2 certified facilities' Downstream vendors	Individuals consumers
Corporate buyers and electronics retailers	NGOs (waste management, environmental, labor practices, etc.)
Certification bodies (auditors)	Multinational industry bodies
Electronics and components manufacturers	ESG reporting standards bodies
	Academia (e.g. LCAs, study of circularity)

Logic Model

The analysis continued with a depiction of SERI's Logic Model. The following tables show the logic model, identifying the planned inputs, activities, and outputs for the SERI R2 certification. From there, the logic model describes the outcomes accruing from all those activities conducted. These outcomes can be distinguished by whether they were short-term outcomes, intermediate outcomes or long-term outcomes (those achieved indirectly from the short-term and intermediate outcomes achieved). Last are the impacts directly attributed to the SERI R2 certification.

The logic model serves as the map of the analysis, as intermediate and long-term outcomes are those that are quantified and/or monetized, as feasible. Of note, while pursuing monetization for all those pathways identified in the Logic Model (i.e. the horizontal paths across the model), inevitably some have a better evidence base than others, and in some cases, the data is too lacking to pursue monetization with a reasonable causal understanding. The following sections will describe in detail those pathways that were successfully monetized, and if not monetized, quantified.

Logic Model Key

How to Read It

Read from left to right, with each column collectively influencing the column to its right and being influenced by the column on its left.

Relationships Between Columns

Individual lines do not necessarily link directly to those immediately on their left or right, although these specific causal chains will be established in our next steps.

Purpose

Connects "Inputs", those resources required to begin, with the projected final "Impact" resulting and attributed to the SERI R2 certification.

In Comparison to What

Outcomes and Impact described in the logic model are assumed to be in comparison to not obtaining the SERI R2 certification.

Inputs

- Electronic devices

Facilities:
- R2 facilities' management
- R2 facilities' workers

SERI:
- SERI team
- R2 certification
- Reporting tools (survey)
- Technical guidance
- Training materials
- Code of practices

Other direct stakeholders:
- Accredited certifying bodies (auditors)
- R2 supplier facilities
- R2 downstream vendors
- Corporate buyers and electronics retailers

Activities

SERI:
- Provide support to R2 facilities' staff
- Stakeholder engagement to conduct revisions and updates of R2 certification
- Update R2 certification process and Code of Practices
- Standard development and technical advisory committee meetings
- Outreach activities to governments and businesses
- Quality control through audit package reviews (assurance) and spot inspections
- Train auditors
- Working groups meetings

Facilities:
- Investment in facilities, processes, and education to comply with R2 certification
- Electronic devices collection
- Electronic devices data sanitization
- Electronic devices test and repair
- Electronic devices refurbishment
- Electronic devices dismantling and components' recovery
- Electronic devices' components recycling
- Electronic devices brokering
- Undergo R2 audits
- Community engagement activities/events

Outputs

Facilities:
- Tons/Number of devices received from R2 and non-R2 suppliers
- Tons/Number of devices sent to an R2 and non-R2 downstream vendor
- % of facilities reporting having an R2 and non-R2 supplier
- % of facilities reporting having an R2 and non-R2 downstream vendor
- Tons/Number of devices sanitized
- Tons/Number of devices tested and repaired
- Tons/Number of devices' components recovered
- Tons/Number of devices' components recycled
- Tons/Number of devices reused
- Number of new hires per year at R2 facilities
- Number of employees at all R2 facilities
- Number of staff trained in certification process and best practices

SERI:
- Number of R2-certified facilities (globally, by region, by country)
- Number of new R2 facilities per year
- Number of prospective facilities engaged per year by SERI
- Number of facilities with suspended or withdrawn/revoked certification
- Number of surveys answered
- Number of audit package reviews and spot inspections

Certification bodies:
- Number of certification bodies (by region)
- Number of newly trained auditors
- Number of auditors
- Number of NC's (non-conformance) identified

Facilities community engagement:
- Number of permanent public drop-off locations
- Tons/Number of devices collected at public drop-off locations
- Number of community events
- Tons/Number of devices collected at community events
- Tons/Number of devices donated
- Tons/Number of devices sold at low-cost
- Number of people accessing trainings

Short-term Outcomes

- Increased number of R2-certified facilities
- Increased tons/number of devices received from R2 suppliers
- Increased tons/number of devices sent to an R2 downstream vendor
- Increased tons/number of devices sanitized
- Increased tons/number of devices tested and repaired
- Increased tons/number of devices refurbished
- Increased tons/number of devices' components recovered
- Increased tons/number of devices' components recycled
- Increased tons/number of devices reused
- Increased documentation of used electronics flows
- Increase in local access to free used electronics disposal
- Increased access to free/low cost electronics for low-income populations

Intermediate Outcomes	Long-term Outcomes	Longer-term Outcomes
Workers		
• Reduced incidence of informal recycling • Improved working conditions and labor rights in the recycling sector (e.g. avoided exposure to toxins) • Increased job creation in the certified used electronics sector • Higher worker professionalization	• Improved livelihoods via new jobs created in the recycling sector • Reduced risk of negative health effects (variable by country and context) • Lower workplace injury rates	• Potential increased earnings (variable by context) • Reduced healthcare costs (variable by country and context)
Local Communities		
• Reduced materials going to landfills	• Reduced pollution in soil, water, and air	• Reduced public health burden from used electronics toxins • Reduced healthcare costs (variable by country and context)
Global Society		
• Energy savings from less use of virgin resources • Increased data on used electronics flows from initial collection to final disposition	• Lower global C02 emissions via reuse and recycling of electronic devices • Decreased illegal exports and dumping rates (variable by country and context) • Increased digital inclusion from accessible electronics	• Reduced social costs of carbon • Reduced public health burden from used electronics dumping • Increased participation in digital economy
Businesses (Electronics Users)		
• Improved data security • Increased confidence in recycling electronics • Streamlined used electronics management • Potential reduced insurance costs	• Reduced risk of data breaches, identity theft, and potential legal liabilities • Higher compliance with environmental standards • Increased trust from shareholders	• Improved brand reputation • Reduced Scope 3 emissions • Higher competitive advantage • Increased new business opportunities • Potential increase in revenues
Facilities Processing Electronics		
• Increased operational efficiency for certified facilities • Increased market differentiation • Improved reputation • Reduced legal risks • Increased compliance and audit costs • Increased recovery of materials	• Increased cost savings • Increased access to high-value contracts (such as OEMs and governments) • Increased preparation for future regulation	• Potential increase in revenues
Consumers		
• Decreased number of new electronic devices purchased • Increased demand for refurbished electronics • Increased use of electronics in low-income populations • Increased confidence in recycling electronics	• Cost savings to consumers from cheaper electronics (reused) • Increased likelihood of intentional recycling of electronics	

Impact

- Increased wellbeing for workers, consumers, and local communities
- Potential increased wealth (variable by context)
- Increased climate risk mitigation
- Growing formal repair/refurbishment markets
- Increased consumption responsibility
- Increased product circularity
- Decreased digital divide

Scope of Analysis

Ecotone collaborated with the SERI team to develop the scope of this analysis. The process involved understanding the R2 certification process, how it compares to other approaches in the electronics processing industry, and identifying the key differentiators between certified, uncertified, and informal processing pathways. This was paired with Ecotone's review of secondary research, exploring available evidence on used electronics processing and the impacts of formalization and certification.

Monetized Outcomes

Table 1. Sampling of Prominent Outcomes Projected for 2024

Region	Impact Area	Projected Benefit per Person/per Device	Regional Projected Benefit	Description
U.S.	Health Benefits	$240	$4,786,320	Avoided workplace injury or illness due to ISO 45001 certification (required as a part of R2)
North America	Health Benefits	$539	$21,423,942	Avoided loss of lifetime earnings due to high Blood Lead Levels (BLL) and reduced IQ
Global	Environmental Benefits	$2.80	$40,655,720	Total Estimated value of GHG emissions avoided from a 10 percentage point increase in Laptops reused by R2 facilities compared to formal but uncertified facilities
Global	Environmental Benefits	$0.08	$117,953	Total Estimated value of GHG emissions avoided from a 10 percentage point increase in Flat Panel Monitors recycled by R2 facilities compared to formal but uncertified facilities

The analysis also projected quantified but non-monetized outcomes such as the number of avoided cases of cancer and the number of new jobs created through refurbishing and repairing used electronics.

Outcomes Estimates

Outcome: Avoided healthcare costs due to reduced likelihood of developing cancer - South America

Projected Marginal Benefit: $1,877
Estimation Calculation: 592 * 1.44 * 0.278 * $7.92
Counterfactual: Informal

Figure 1: 592

Type: Total number of SERI facilities' employees

Source: SERI survey data

Figure 2: 1.44

Type: Likelihood of dying from cancer-related causes due to elevated BLL

Notes: A study of the NHANES III population, reported that those who had BLLs at a baseline of 5–10 µg/dL were 1.44 times as likely to die from cancer-related causes as those who had BLLs under 5 µg/dL, and those who had BLLs of 10 µg/dL or higher were 1.69 times as likely to die from cancer-related causes as the referent group.

The BLL found in used electronics workers for South America is:

- South America (Uruguay): Children and adolescents exposed to lead through burning cable activities: Average BLLs at first consultation were 9.19 ug/dL

Source: Schober et al., 2006; Jorfi et al., 2024; Pascale et al., 2016; Simon et al., 2024.

Figure 3: 0.278

Type: Baseline probability of developing cancer

Notes: Baseline probability of developing cancer per country.

Source: Global Cancer Observatory's Cancer Today heatmap

Figure 4: $7.92

Type: Baseline cost of developing cancer

Notes: The overall mean expenditure per new cancer patient in the region is US $7.92 compared with US $183, US $244, and US $460 spent by the United Kingdom, Japan, and the United States, respectively. The overall cost of cancer care has been calculated to represent 0.12% of gross national income per capita in South America versus 0.51%, 0.6%, and 1.02% in the United Kingdom, Japan, and the United States, respectively. These statistics highlight the striking inequity and shortage of resources for cancer care and control in Latin America.

Source: Ruiz et al., 2017

Outcomes Estimates

Outcome: Avoided workplace injury or illness due to ISO 45001 certification (required as a part of R2) - North America

Projected Marginal Benefit: $4,768,320
Estimation Calculation: 19,868 * 0.2 * 0.04 * $30,000
Counterfactual: Formal but uncertified

Figure 1: 19,868

Type: Total number of SERI facilities' employees in North America

Source: SERI survey data

Figure 2: 0.2

Type: Percent reduction in illness and injury at the workplace due to OHSAS 18001 certification

Notes: Using propensity score matching and a difference-in-differences approach, we estimate that OHSAS 18001 certification reduces the total number of illness and injury cases by 20 percent and illness and injury cases associated with job transfers or restrictions by 24 percent.

Given that OHSAS 18001 is the basis for the newer ISO 45001 standard that has quickly become the world's third-most popular management system standard, this study provides promising evidence that ISO 45001 will also prove effective in distinguishing safer workplaces.

Source: Viswanathan et al., 2023

Figure 3: 0.04

Type: Number of incidents of work-related injuries and illness in the waste industry per 100 FTEs

Notes: Incidents of work-related injuries and illness in the waste industry reached their lowest levels in years in 2021, according to annual data released by the U.S. Bureau of Labor Statistics (BLS) on Wednesday. For solid waste collection workers, the rate was 4.0 total cases per 100 full-time equivalent (FTE) workers, down from the previous year's 5.2.

Source: https://www.wastedive.com/news/bls-injury-illness-waste-recycling-workers-2021/636234/

Figure 4: $30,000

Type: Costs of Workplace Injuries

Notes: U.S. average medically treated injury: ~$39–42k; fatalities ~$1.15M

Source: https://www.osha.gov/safetypays/estimator

Outcomes Estimates

Outcome: Avoided workplace injury or illness associated with job transfers or restrictions due to ISO 45001 certification (required as a part of R2) - North America

Projected Marginal Benefit: $2,431,843
Estimation Calculation: 19,868 * 0.24 * 0.017 * $30,000
Counterfactual: Formal but uncertified

Figure 1: 19,868

Type: Total number of SERI facilities' employees in North America

Source: SERI survey data

Figure 2: 0.2

Type: Percent reduction in illness and injury at the workplace due to OHSAS 18001 certification

Notes: Using propensity score matching and a difference-in-differences approach, we estimate that OHSAS 18001 certification reduces the total number of illness and injury cases by 20 percent and illness and injury cases associated with job transfers or restrictions by 24 percent.
Given that OHSAS 18001 is the basis for the newer ISO 45001 standard that has quickly become the world's third-most popular management system standard, this study provides promising evidence that ISO 45001 will also prove effective in distinguishing safer workplaces.

Source: Viswanathan et al., 2023

Figure 3: 0.017

Type: Number of cases of associated with job transfers and restricts in the goods-producing industries per 100 FTEs

Notes: 1.7 DART cases per 100 FTE in "Goods-producing" industries (which includes manufacturing and recycling) for private sector

Source: https://www.bls.gov/web/osh/table-1-industry-rates-national.htm

Figure 4: $30,000

Type: Costs of Workplace Injuries

Notes: U.S. average medically treated injury: ~$39–42k; fatalities ~$1.15M

Source: https://www.osha.gov/safetypays/estimator

Outcomes Estimates

Outcome: Improved access to smartphones due to donations to low income communities – North America

Projected Marginal Benefit: $437
Estimation Calculation: 1 *$437
Counterfactual: N/A

Figure 1: 1

Type: Donated smartphone

Source: SERI survey data

Figure 2: $437

Type: Willingness to pay for access to a smartphone for 1 year

Notes: The authors estimate that the consumers' willingness to pay implied from the demand function for access to a smartphone for 1 year is $437.16.

Source: Brynjolfsson et al., 2018

Outcomes Estimates

Outcome: Avoided healthcare costs of high BLL in children - North America

Projected Marginal Benefit: $2,122,300
Estimation Calculation: 39,736*0.49*0.2*$109
Counterfactual: Formal but uncertified

Figure 1: 39,736
Type: Total number of SERI facilities' employees' children
Source: SERI survey data

Figure 2: 0.49
Type: Likelihood of children having elevated BLL due to parents bringing lead dust in working clothes
Notes: During November 2010–May 2011, four voluntary blood lead screening clinics for children of employees of a battery recycling facility in Puerto Rico were conducted. A total of 227 persons from 78 families had blood lead tests. [...] To determine whether take-home lead exposure contributed to the children's BLLs of ≥10 µg/dL, vehicle and household environmental samples were collected and analyzed. Eighty-five percent of vehicle dust samples and 49% of home dust samples exceeded the U.S. Environmental Protection Agency (EPA) level of concern of ≥40 µg/ft2 (3.7 µg/m2).
Source: Centers for Disease Control and Prevention [CDC], 2012.

Figure 3: 0.2
Type: Likelihood of high concentrations of lead in home dust (>40 ug/sq ft) leading to a BLL in children in that home higher than 10 ug/dL.
Notes: For dust lead standards of 5 micrograms/sq ft, 20 micrograms/sq ft, and 40 micrograms/sq ft on non carpeted floors, the estimated percentages of children having blood lead levels at or above 10 micrograms/dL were 4%, 15%, and 20%, respectively, after adjusting for other significant covariates.
Source: Lanphear et al., 1996

Figure 4: $109
Type: Inflation-adjusted cost of treating high BLL in children
Notes: For children with levels ranging from 10 to 20 µg/dL, further diagnostic testing is required, necessitating venipuncture and a lead assay, followed by an additional nurse-only visit, for a total cost of $74 per child.
Source: Gould, 2009

Outcomes Estimates

Outcome: Avoided loss of lifetime earnings due to high BLL and reduced IQ - North America

Projected Marginal Benefit: $21,423,942
Estimation Calculation: 39,736*0.49*0.2*0.153*0.41*$109
Counterfactual: Formal but uncertified

Figure 1: 39,736
Type: Total number of SERI facilities' employees' children
Source: SERI survey data

Figure 2: 0.49
Type: Likelihood of children having elevated BLL due to parents bringing lead dust in working clothes
Notes: During November 2010–May 2011, four voluntary blood lead screening clinics for children of employees of a battery recycling facility in Puerto Rico were conducted. To determine whether take-home lead exposure contributed to the children's BLLs of ≥10 µg/dL, vehicle and household environmental samples were collected and analyzed. Eighty-five percent of vehicle dust samples and 49% of home dust samples exceeded the U.S. EPA evel of concern of ≥40 µg/ft2 (3.7 µg/m2).
Source: Centers for Disease Control and Prevention [CDC], 2012.

Figure 3: 0.2
Type: Likelihood of high concentrations of lead in home dust (>40 ug/sq ft) leading to a BLL in children in that home higher than 10 ug/dL.
Notes: For dust lead standards of 5 micrograms/sq ft, 20 micrograms/sq ft, and 40 micrograms/sq ft on non carpeted floors, the estimated percentages of children having blood lead levels at or above 10 micrograms/dL were 4%, 15%, and 20%, respectively, after adjusting for other significant covariates.
Source: Lanphear et al., 1996

Figure 4: 0.153
Type: Average IQ point loss per µg/dL
Notes: A variety of studies analyze the effects of high BLLs on intellectual function, most frequently quantified by IQ. Lanphear et al. (2005) have established a clear nonlinear, negative relationship between IQ and BLL based on pooled international data. The rate of IQ loss is greatest per unit blood lead < 10 µg/dL. We assume that by eliminating lead dust being brought home by parents, the blood lead level of their children is reduced by at least 1 µg/dL.
Source: Gould, 2009

Figure 5: 0.41
Type: Proportion of children with BLL between 2 - 10 µg/dL
Notes: Among 68 children aged <6 years, 11 (16%) had confirmed BLLs ≥10 µg/dL, and 28 (41%) had BLLs 5–9 µg/dL (Figure). Additionally, four (7%) of 56 children aged 6–17 years, and 44 (42%) of 105 adults aged 18–68 years also had confirmed BLLs ≥10 µg/dL.
Source: Centers for Disease Control and Prevention [CDC], 2012.

Figure 6: $109
Type: Inflation-adjusted cost of treating high BLL in children
Notes: For children with levels ranging from 10 to 20 µg/dL, further diagnostic testing is required, necessitating venipuncture and a lead assay, followed by an additional nurse-only visit, for a total cost of $74 per child.
Source: Gould, 2009

Outcomes Estimates

Outcome: Avoided healthcare costs of ADHD treatment due to high BLL in children - North America

Projected Marginal Benefit: $445,706
Estimation Calculation: 39,736*0.49*0.2*0.114*$1,004
Counterfactual: Formal but uncertified

Figure 1: 39,736

Type: Total number of SERI facilities' employees' children

Source: SERI survey data

Figure 2: 0.49

Type: Likelihood of children having elevated BLL due to parents bringing lead dust in working clothes

Notes: During November 2010–May 2011, four voluntary blood lead screening clinics for children of employees of a battery recycling facility in Puerto Rico were conducted. To determine whether take-home lead exposure contributed to the children's BLLs of ≥10 µg/dL, vehicle and household environmental samples were collected and analyzed. Eighty-five percent of vehicle dust samples and 49% of home dust samples exceeded the U.S. EPA level of concern of ≥40 µg/ft2 (3.7 µg/m2).

Source: Centers for Disease Control and Prevention [CDC], 2012.

Figure 3: 0.2

Type: Likelihood of high concentrations of lead in home dust (>40 ug/sq ft) leading to a BLL in children in that home higher than 10 ug/dL.

Notes: For dust lead standards of 5 micrograms/sq ft, 20 micrograms/sq ft, and 40 micrograms/sq ft on non carpeted floors, the estimated percentages of children having blood lead levels at or above 10 micrograms/dL were 4%, 15%, and 20%, respectively, after adjusting for other significant covariates.

Source: Lanphear et al., 1996

Figure 4: 0.114

Type: Likelihood of children developing ADHD

Notes: An estimated 7 million (11.4%) U.S. children aged 3–17 years have ever been diagnosed with ADHD, according to a national survey of parents using data from 2022.

Source: Lanphear et al., 1996

Figure 5: $1,004

Type: Inflation-adjusted cost of treating ADHD in children

Notes: Of the 1.8 million ADHD cases in children 4–15 years of age, 21.1%, or 290,000, are linked to BLLs > 2 µg/dL (Braun et al. 2006). Assuming average medical treatment costs per child of $565 for drug and counseling therapy and average parental work loss costs of $119 per child, lead exposure costs $267 million annually to individual families and society. Because the costs of medical treatment and work losses are likely to increase greatly with the severity of the condition, these estimates represent a conservative lower bound for the total costs of lead-linked ADHD cases.

Source: Gould, 2009

Outcomes Estimates

Outcome: Avoided costs of future criminal activity

Projected Marginal Benefit: $44,367
Estimation Calculation: 39,736*0.49*0.000387*$5,888
Counterfactual: Formal but uncertified

Figure 1: 39,736 - North America

Type: Total number of SERI facilities' employees' children per region

Source: SERI survey data

Figure 2: 0.49

Type: Likelihood of children having elevated BLL due to parents bringing lead dust in working clothes

Notes: During November 2010–May 2011, four voluntary blood lead screening clinics for children of employees of a battery recycling facility in Puerto Rico were conducted. A total of 227 persons from 78 families had blood lead tests. [...] To determine whether take-home lead exposure contributed to the children's BLLs of ≥10 µg/dL, vehicle and household environmental samples were collected and analyzed. Eighty-five percent of vehicle dust samples and 49% of home dust samples exceeded the U.S. Environmental Protection Agency (EPA) level of concern of ≥40 µg/ft2 (3.7 µg/m2).

Source: Centers for Disease Control and Prevention [CDC], 2012.

Figure 3: 0.000387

Type: Proportion of lead-linked burglaries per resident

Source: Gould, 2009

Figure 4: $5,888

Type: Inflation-adjusted direct cost of crime

Notes: Medical and economic research has established a connection between early childhood lead exposure and future criminal activity, especially of a violent nature. [...] A 1-µg/dL reduction in the average pre-school BLL results in 116,541 fewer burglaries, 2,499 fewer robberies, 53,905 fewer aggravated assaults, 4,186 fewer rapes, and 717 fewer murders. The total direct cost of lead-linked crimes is approximately $1.8 billion, including direct victim costs, costs related to the criminal justice system through legal proceedings and incarceration, and lost earnings to both criminal and victim. An additional $11.6 billion is lost in indirect costs, which include psychological and physical damage necessitating medical treatment and preventive measures resulting from the criminal action.

Source: Gould, 2009

Outcomes Estimates

Outcome: Increase in income due to higher likelihood of high school graduation due to donations to low-income communities

Projected Marginal Benefit: $3,750
Estimation Calculation: 1*0.06*0.5*$125,000
Counterfactual: N/A

Figure 1: Donated laptop

Type:

Source: SERI survey data

Figure 2: 0.06

Type: Likelihood of graduation due to access to a laptop

Notes: Teenagers who have access to home computers are 6 to 8 percentage points more likely to graduate from high school than teenagers who do not have home computers after controlling for individual, parental, and family characteristics.

Source: Beltran, Das, & Fairlie, 2008

Figure 3: 0.5

Type: Likelihood that the increase in earnings are due to the educational attainment

Notes: WSIPP estimates a causal factor of about 0.5

Source: WSIPP, 2023

Figure 4: $125,000

Type: Increased in future income due to having highschool diploma

Notes: Difference in earnings between those who have a HSE vs. no HSE estimated at $125,000 using ACS data.

Source: https://www.ssa.gov/policy/docs/research-summaries/education-earnings.html

Outcomes Estimates

Outcome: Total Estimated GHG emissions avoided from additional *Mobile Phones* reused by R2 facilities compared to formal but uncertified facilities *(This is an example of the GHG estimation process - GHG estimation details starting on slide 104)*

Projected Marginal Benefit: $ 29,836,420
Estimation Calculation: 53,279,321 * 0.1 * 40 * $0.14
Counterfactual: Formal but uncertified

Figure 1: 53,279,321
Type: # of mobile phones processed by R2 facilities in 2024
Source: SERI survey data

Figure 2: 0.1
Type: ASSUMED Increased likelihood of a laptop processed by R2 facilities to be reused
Notes: This figure is an assumed value for the sake of showcasing the potential scale of value generated by R2 facilities. This value appears realistic based on existing data points however data is scarce and quite variable.
Source: Assumed value

Figure 3: 40
Type: GHG emissions avoided due to reuse of mobile phone (kg of CO2e)
Notes: Ranges from 40-50 kg of CO2e - the lower value is used to remain conservative.
iPhone 13: 64 kg CO_2e (128 GB model)
European Investment Bank case-study: refurbished phones have a 78 % lower footprint than new reducing from 80 kg to ≈ 18 kg CO_2e
Source: Apple LCA, 2023; European Investment Bank, 2023

Figure 4: $0.14
Type: Social Cost of Carbon per Kg
Notes: Social cost of Carbon: $54- $236 per tonne. This translates to $0.05 per kg as a conservative lower bound estimate. We will use a mid-point estimate of $0.14 per kg.
Source: Chadwick et al., 2023; IFVI, 2024

Outcomes Estimates

Outcome: Total Estimated GHG emissions avoided from additional *Laptops* reused by R2 facilities compared to formal but uncertified facilities *(This is an example of the GHG estimation process - additional GHG estimation details starting on slide 104)*

Projected Marginal Benefit: $40,655,720
Estimation Calculation: 14,519,900 * 0.1 * 200 * $0.14
Counterfactual: Formal but uncertified

Figure 1: 14,519,900
Type: # of laptops processed by R2 facilities in 2024
Source: SERI survey data - about 87% of all laptops processed by R2 facilities in 2024 were sold for reuse.

Figure 2: 0.1
Type: ASSUMED Increased likelihood of a laptop processed by R2 facilities to be reused
Notes: This figure is an assumed value for the sake of showcasing the potential scale of value generated by R2 facilities. This value appears realistic based on existing data points however data is scarce and quite variable.
Source: Assumed value

Figure 3: 200
Type: GHG emissions avoided due to reuse of laptop (kg of CO2e)
Notes: Conservatively anges from 200-250 kg of CO2e - the lower value is used to remain conservative
Industry meta-average 331 kg CO_2-eq
Cranfield-University peer-reviewed study: remanufactured laptops emit 6.34 % of a new device → ≈ 21 kg CO_2-eq
Source: Yuksek et al., 2022; Foxway, 2023

Figure 4: $0.14
Type: Social Cost of Carbon per Kg
Notes: Social cost of Carbon: $54- $236 per tonne. This translates to $0.05 per kg as a conservative lower bound estimate. We will use a mid-point estimate of $0.14 per kg.
Source: Chadwick et al., 2023; IFVI, 2024

Quantified but Non-monetized Outcomes

Outcomes Estimates

Outcome: Reduced number of cancer cases avoided - several regions

Projected Marginal Benefit: 32,801
Estimation Calculation: 124,221 * (1.69 * 0.155) + 592 * (1.44 * 0.278) + 115 * (1.44 * 0.146)
Counterfactual: Combined Informal and formal but uncertified (for sake of communicating all estimates)

Figure 1: 124,221 / 592 / - Asia / South America /
Type: Total number of SERI facilities' employees
Source: SERI survey data

Figure 2: 1.69 / 1.44 / 1.44 - Asia / South America / Africa
Type: Likelihood of dying from cancer-related causes due to elevated BLL

Notes: A study of the NHANES III population, reported that those who had BLLs at a baseline of 5–10 μg/dL were 1.44 times as likely to die from cancer-related causes as those who had BLLs under 5 μg/dL, and those who had BLLs of 10 μg/dL or higher were 1.69 times as likely to die from cancer-related causes as the referent group.

The BLL found in used electronics workers for different regions are:

- Asia (Iran): Upon measuring the lead concentration in the dust of recycling workshops and the used electronics in southwestern region of Iran: 24 μg/dL
- South America (Uruguay): Children and adolescents exposed to lead through burning cable activities: Average BLLs at first consultation were 9.19 ug/dL
- Africa (Tanzania): The mean Blood Lead Level was 9.36 μg/dL and 17.30 μg/dL for Factory A Factory B respectively.

Source: Schober et al., 2006; Jorfi et al., 2024; Pascale et al., 2016; Simon et al., 2024.

Figure 3: 0.155 / 0.278 / 0.146 - Asia / South America / Africa
Type: Baseline probability of developing cancer
Notes: Baseline probability of developing cancer per country.
Source: Global Cancer Observatory's Cancer Today heatmap

Outcomes Estimates

Outcome: Increase in number of jobs from refurbishing/repair vs. recycling alone

Projected Marginal Benefit: 63 additional jobs supported in 2024
Estimation Calculation: 3,146 * 0.1 * 0.2
Counterfactual: Formal but uncertified

Figure 1: 3,146
Type: Tonnes of electronics repaired for reuse
Notes: In 2024, R2 facilities were estimated to repair 3,146 tonnes of electronics (not including recycling).
Source: SERI survey data

Figure 2: 0.1
Type: Additional proportion of devices being reused due to certification
Notes: R2 facilities are estimated to conservatively, on average repair and reuse about 10 percentage points more electronics than formal but uncertified facilities.
Source: Cascade ITAD Benchmarking report 2024; US International Trade Commission, 2013; EPA Implementation Study of the Electronics Recycling Standards, 2016; https://www.wired.com/2010/08/st-ewaste/

Figure 3: 0.2
Type: Additional jobs per tonne of used electronics repaired
Notes: Another study estimated that for every 1,000 tonnes of used electronics processed, 30 jobs are created in landfills, 15 jobs are created in sorting and recycling, and 200 jobs are generated in repairing.

An older study from Massachusetts, United States, calculated that electronics recycling supported ten times more jobs than land filling, and grading for parts and resale generated over 100 times more jobs than recycling.

Source: K. Sampson: "How used electronics Recycling Is Creating A Lot Of Jobs" (2015).; Massachusetts Department of Environmental Protection: Electronics Re-Use and Recycling Infrastructure Development in Massachusetts (United States Environmental Protection Agency, (2000).

F. GHG Emissions Reduction Calculations

The following tables provide details of the greenhouse gas emission benefit estimations.

Table 35: Per Unit GHG Emissions

	Mobile Phones	Laptops	Flat-Panel Display Monitor (24")	CRTs (15-23 kg set)	Batteries (100-300 g batteries)	Hard Drives (4-8 TB Seagate)
Savings from Recycling	0.24 kg CO_2-eq per phone (EPA WARM)	1.9 kg CO_2-eq per laptop (EPA WARM)	1.10 kg CO_2-eq per kg of monitor (EPA WARM) -- 5 kg monitor = 5.5 kg of CO2e avoided	19-26 kg CO2e (EPA WARM; Van Eygen et al., 2016)	Mobile Phone: 0.46 kg CO_2 saved per battery when going Hydromet route (Machala et al., 2025) Laptop ≈ 2.9 kg CO_2 saved when going Hydromet route	Minimal net GHG benefit
Savings from Reuse	40–50 kg CO_2e per phone (Apple Iphone 13 LCA; European Investment Bank, 2024)	~200–250 kg CO_2e per laptop (Yuksek et al., 2022; Foxway, 2023)	Depends on if LCD vs. LED monitor - keeping lower efficiency monitor in may have worse GHG because of higher energy use - so up to 100 kg co2e savings in low carbon energy grid but could be additional 100 kg co2e if a coal heavy grid over a 10 year lifespan of the monitor. (Dell LCA, 2019; HP LCA, 2023)	Not applicable - assume minimal to no reuse occurring.	.6 kg co2e per phone battery and 4 kg co2e per laptop battery (Wralsen, Benedikte & O'Born, Reyn. 2023)	4-50 kg CO2e depending on type of drive (Seagate Technology. (2013)

F. GHG Emissions Reduction Calculations

Table 36: Laptops have the largest potential GHG benefit per device

	Kg CO2e saved from additional rates of reuse by R2 facilities, per unit			
Increased rate of reuse	5 percentage point	10 percentage point	20 percentage point	40 percentage point
Mobile Phones	2	4	8	16
Laptops	10	20	40	80
Flat-Panel Display Monitor (24")	4.9	9.8	19.6	39.2
Hard Drives - 3.5" HDD Enterprise	2.6	5.2	10.4	20.8
Hard Drives - 3.5" HDD Personal	0.45	0.9	1.8	3.6
Hard Drives - Laptop SSD	0.2	0.4	0.8	1.6

F. GHG Emissions Reduction Calculations

Table 37: Reuse of laptops has the largest GHG benefit per device (amongst those devices analyzed)

	$ saved per unit from additional rates of reuse by R2 facilities			
Increased rate of reuse	5 percentage point	10 percentage point	20 percentage point	40 percentage point
Mobile Phones	$0.29	$0.580	$1.16	$2.32
Laptops	$1.45	$2.90	$5.80	$11.60
Flat-Panel Display Monitor (24")	$0.71	$1.42	$2.84	$5.68
CRTs (15-23 kg set) (recycled)	$0.38	$0.75	$1.51	$3.02
Batteries - Laptop (recycled)	$0.07	$0.13	$0.26	$0.52
Batteries - Phone (recycled)	$0.03	$0.06	$0.12	$0.23

F. GHG Emissions Reduction Calculations

Table 38: CRTs have the largest potential GHG impact due to recycling amongst those devices analyzed here

	Kg CO2e saved from additional rates of recycling by R2 facilities, per unit				
Increased rate of recycling	5 percentage point	10 percentage point	20 percentage point	40 percentage point	Notes
Mobile Phones	0.012	0.024	0.048	0.096	
Laptops	0.095	0.19	0.38	0.76	
Flat-Panel Display Monitor (24")	0.275	0.55	1.1	2.2	Assumes average global electricity grid, LCD monitor 5 year lifespan extension before a new LED monitor
CRTs (15-23 kg set) (recycled)	0.95	1.9	3.8	7.6	Assumes average global electricity grid and 3 year life extension
Batteries - Laptop (recycled)	0.145	0.29	0.58	1.16	
Batteries - Phone (recycled)	0.023	0.046	0.092	0.184	

F. GHG Emissions Reduction Calculations

Table 39: Social costs of carbon avoided are largest when maximizing the recycling of CRTs

	$ saved per unit from additional rates of recycling by R2 facilities			
Increased rate of recycling	5 percentage point	10 percentage point	20 percentage point	40 percentage point
Mobile Phones	$0.00	$0.003	$0.01	$0.01
Laptops	$0.01	$0.03	$0.06	$0.11
Flat-Panel Display Monitor (24")	$0.04	$0.08	$0.16	$0.32
CRTs (15-23 kg set) (recycled)	$0.14	$0.28	$0.55	$1.10
Batteries - Laptop (recycled)	$0.02	$0.04	$0.08	$0.17
Batteries - Phone (recycled)	$0.00	$0.01	$0.01	$0.03

G. Social Cost of Carbon

The social cost of carbon (SCC) estimates the cost of climate damages from a single extra tonne of CO_2. There are several estimates out there due to the significant sensitivity to assumptions used including the discount rates, impact models, and socioeconomic pathways used. Recent U.S. estimates show this variability: the Biden administration's 2021 interim figure of $51/t$CO_2$ (3 % discount rate) versus the U.S. EPA's 2023 draft estimate of about $190/t$CO_2$ which used a different climate damage model and utilized a dynamic 2% discount rate.

The International Foundation for Valuing Impacts (IFVI) goes further—its 2024 impact-accounting methodology averages the estimates from two damage models to publish a value factor of $236/t$CO_2$e for 2023 emissions (rising to $239 in 2024) (IFVI, 2024). The higher figures generally reflect a broader damage menu (e.g., labor productivity, energy demand, sea-level rise) and lower discounting of far-future harms, illustrating why the social cost of carbon can rise sharply as science and ethics evolve (RFF, 2025).

Estimates also diverge across institutions and policy purposes. The UK government's "central" carbon value for policy appraisal is £260/tCO_2 in 2025 (with £130–390 low–high bounds) (UK Government, 2021). By contrast, the International Monetary Fund's (IMF) proposed International Carbon Price Floor is intentionally pragmatic, calling for differentiated $25 / $50 / $75 per-ton floors by 2030 for low-, middle-, and high-income countries to spur cooperative action (IMF, 2022).

Despite these differences and wide ranges, Ecotone leverages a mid-point estimate in between the 2021 Biden Administration estimate and the value used by the IFVI, which results in a social cost of carbon of about $145 per tonne.

References:

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H. FAQs

About the Methodology

What was the purpose of this analysis?

This impact analysis was commissioned by SERI to assess and project the social, environmental, and economic benefits associated with its R2 Certification program. The analysis was conducted by Ecotone Analytics, a firm that specializes in measuring social and environmental impacts. The goal was to better understand the value that R2 Certified facilities create for stakeholders around the world.

What kind of data was used for this report?

The analysis is based on both primary and secondary data. The primary data comes from a 2025 survey of R2 Certified facilities, which provided operational numbers on device volumes and workforce size. This was combined with a review of over 100 external resources, including academic and peer-reviewed studies, to provide evidence for the impact projections.

What does it mean that the outcomes are "projected" or "estimated"?

The report provides estimations of what the impacts of R2 certification could be; it is not a measurement of actual achieved impact. The analysis pairs data from R2 facilities with findings from external literature to project potential outcomes. Because actual benefits may vary based on the specific context of each facility, the report takes a conservative approach to avoid overstating the impacts.

H. FAQs

About the Methodology

What is a "counterfactual" and why was it used?

A counterfactual describes what would have likely occurred in the absence of the R2 Certification. This comparison is essential to attribute impact directly to the certification itself. The analysis used two main counterfactual scenarios:

- Formal but uncertified facilities: This helps isolate the unique benefits that come from R2's specific standards for data security, environmental management, and worker safety.
- Informal processing: This scenario is used to show how R2 certification helps shift the market toward safer and more accountable operations, especially in regions where informal used electronics handling is common.

How were the financial values of impacts calculated?

The process of assigning a dollar value to impacts is called "monetization". Ecotone Analytics used a combination of methods, including:

- Market Price: Using direct costs, such as the average cost of a workplace injury or medical treatment.
- Benefits Transfer: Applying financial estimates from existing, high-quality studies to the context of R2 certified facilities. For example, using established data on the social costs of lead poisoning and applying it to the electronics recycling industry.

The general formula follows the structure of:
Number of Units * Effect of R2 Certification * The Cost/Value of that Effect.

H. FAQs

About the Findings

Why are there different scenarios for GHG emissions reductions?

There is currently no direct measurement of exactly how much more an R2 facility reuses or recycles compared to a non-R2 facility. Because of this uncertainty, the analysis presents a few scenarios (e.g., a 5%, 10%, or 20% increase in reuse/recycling) to estimate a range of potential GHG savings. Based on market conditions and the R2 Standard's design, the 10% increase is considered a conservative and suitable benchmark for communication.

Why does reusing electronics save more GHG emissions than recycling them?

Reusing a device avoids the energy and virgin materials required to manufacture a new one, which results in substantial GHG savings. While recycling is also impactful, extending the life of an entire device means that, cumulatively, the benefit of reuse is often significantly greater—in some cases, generating 100 times the GHG savings compared to recycling. The analysis estimates that the greatest GHG benefit of R2 certification comes from the reuse of electronics like laptops and mobile phones.

What are "non-monetized impacts" and why are they important?

Non-monetized impacts are significant benefits that are not assigned a dollar value due to data limitations or because they are intangible. They are still essential for understanding the full value of R2 certification. Key examples include:

- Reduced Risk of Data Breaches: R2's strict data destruction standards protect individuals and organizations from identity theft and legal liabilities.
- Decreased Environmental Pollution: Diverting electronics from landfills prevents hazardous substances from contaminating soil and groundwater.
- Improved Consumer Trust: The R2 seal enhances brand reputation and signals a commitment to responsible electronics management.

H. FAQs

About the Findings

How does R2 Certification create jobs?

The processes of refurbishing and repairing electronics create significantly more jobs than landfilling or recycling alone. For every 1,000 tonnes of used electronics processed, repair activities generate an estimated 200 jobs, compared to just 15 for recycling and sorting. Because R2 facilities have higher rates of reuse and repair, they are estimated to support 63 additional jobs compared to non-certified facilities.

How does R2 Certification align with the UN Sustainable Development Goals (SDGs)?

The analysis mapped the impacts of R2 certification to several UN SDGs, which serve as a global blueprint for addressing the world's most pressing challenges. R2 certification directly contributes to:

- SDG 3 (Good Health & Well-being): By controlling hazardous materials like lead and mercury, reducing health risks for workers and communities.
- SDG 8 (Decent Work & Economic Growth): By banning child labor and requiring certified safety management systems that create safer workplaces.
- SDG 12 (Responsible Consumption & Production): By promoting a circular economy hierarchy that prioritizes reuse over recycling.
- SDG 13 (Climate Action): By delivering substantial greenhouse gas emission cuts through the reuse and responsible recycling of electronics.

5.6 Major Customers

The first table below shows the distribution of primary client industries served by R2 certified facilities across different global regions. The data highlights that IT, electronics, and mobile phone companies are the top revenue-generating customers, especially in North America (166 facilities) and Asia (49 facilities), contributing to a global total of 251. Other significant sectors include Retail Sales (157 total), Data Centers (135 total), and Telecommunications (127 total). North America consistently reports the highest number of customer engagements across nearly all sectors, followed by Asia and Europe. Less represented sectors include Legal Services, Research and Development, and Food Service, which show very limited presence globally.

The second table summarizes the major supplier sectors for R2 certified facilities across different global regions. The IT/electronics/mobile phone sector was the most frequently reported supplier across all regions, with 279 facilities indicating it as one of their top sources, most prominently in North America (182) and Asia (64). Other top sectors include Data Centers (156 total), Telecommunications (148), and OEMs (143). North America consistently shows the highest number of responses across most supplier categories, suggesting a more diversified supplier base, followed by Asia. Oceania and South America show modest but noticeable contributions in sectors such as Finance/Insurance/Banking, Public sector, and OEMs. The relatively high number of facilities identifying Retail Sales (111), Education (118), and Healthcare (82) as suppliers also points to the increasing circularity of electronics within institutional and consumer-facing sectors. This table highlights where the bulk of used or surplus electronic equipment originates and reinforces the role of corporate and public institutions in supporting electronics reuse and recycling.

Table 10. R2 facilities' major customers by revenue

Major customers sectors by revenue							
Customer Sector	Africa	Asia	Europe	North America	Oceania	South America	Grand Total
IT/electronics/mobile phone	[redacted]	49	16	166	12	6	[redacted]
Retail Sales	[redacted]	34	6	111	1	4	[redacted]
Data Centers	[redacted]	25	14	85	4	6	[redacted]
Telecommunications	[redacted]	20	2	93	2	10	[redacted]
OEMs	[redacted]	20	6	70	3	9	[redacted]
Fin Serv/Ins/Banking	[redacted]	21	3	55	11	4	[redacted]
Public sect/govt (not cover)	[redacted]	4	3	56	15	0	[redacted]
Education	[redacted]	4	3	63	5	1	[redacted]
Healthcare	[redacted]	7	0	58	1	1	[redacted]
Ship/distr/rev log/3PL/wareh	[redacted]	7	1	39	2	4	[redacted]
Manufacturing/construction	[redacted]	20	3	25	1	2	[redacted]
Communications/Media	[redacted]	9	0	29	1	0	[redacted]
Prov/state/fed prod resp pro	[redacted]	1	0	24	4	0	[redacted]
Energy/Utilities	[redacted]	3	0	21	0	0	[redacted]
Legal Services	[redacted]	2	3	5	0	1	[redacted]
Entertainment	[redacted]	1	0	9	0	0	[redacted]
Research and development	[redacted]	1	0	9	0	0	[redacted]
Food Service	[redacted]	0	0	4	0	0	[redacted]
Natur resourc extract/prod	[redacted]	1	0	2	0	0	[redacted]
Tourism/hospitality/leisure	[redacted]	0	0	3	0	0	[redacted]

Regional data was redacted for confidentiality purposes.

Table 11. R2 facilities' major suppliers

Major customers sectors by supply							
Values	Africa	Asia	Europe	North America	Oceania	South America	Grand Total
IT/electronics/mobile phone	[redacted]	64	13	182	12	6	[redacted]
Data Centers	[redacted]	32	16	97	4	6	[redacted]
Telecommunications	[redacted]	22	2	111	3	10	[redacted]
OEMs	[redacted]	23	10	95	3	11	[redacted]
Fin services/ins/banking	[redacted]	27	5	71	12	4	[redacted]
Education	[redacted]	11	5	94	7	1	[redacted]
Retail Sales	[redacted]	30	3	74	0	3	[redacted]
Public sect/govt not cover	[redacted]	10	2	75	13	1	[redacted]
Healthcare	[redacted]	10	3	66	1	2	[redacted]
Manufacturing/construction	[redacted]	28	3	46	1	2	[redacted]
Ship/distr/rev log/3PL/war	[redacted]	13	2	56	2	5	[redacted]
Communications/Media	[redacted]	12	0	38	2	0	[redacted]
Prov/st/fed producer resp	[redacted]	2	0	38	4	0	[redacted]
Energy/utilities	[redacted]	4	1	27	1	0	[redacted]
Entertainment	[redacted]	4	0	18	0	0	[redacted]
Legal Services	[redacted]	3	2	10	0	1	[redacted]
Research/Dev	[redacted]	3	0	7	0	0	[redacted]
Food Services	[redacted]	2	0	7	0	0	[redacted]
Nat resources extract/prod	[redacted]	1	0	4	0	0	[redacted]
Tourism/hospit/leisure	[redacted]	3	0	2	0	0	[redacted]

Regional data was redacted for confidentiality purposes.

A. Bibliography

Ecotone's analysis is based on two types of data: 1) program data provided by the client; and 2) evidence from external literature. After analyzing all the program data, Ecotone undertakes a systematic review of evidence by reviewing external literature that aligns with the program's goals, services, and outcomes, relying on sources with higher levels of evidence of causal impact where possible.

The review process begins with a well-defined question, identifies relevant studies, assesses their quality, and uses a clear methodology to summarize the evidence. Over 100 resources were reviewed for this analysis. However, not all of them provided figures that were directly incorporated into the monetized outcome estimations. Some resources were incorporated into the non-monetized outcomes evidence, providing support that an outcome is likely to be experienced, but may not be monetizable at this time.

The five steps for conducting a review of evidence:

Step 1: Framing questions for a review
The problems that the review addresses are defined with clear, structured, and precise questions before starting the review process. Once these questions are established, any changes to the search should be permitted only if new ways of defining the populations, interventions, outcomes, or study designs emerge.

Step 2: Identifying relevant studies
The search for studies is thorough, utilizing a variety of sources and evidence repositories without restricting by language. The criteria for selecting studies aligns directly with the review questions (Step 1) and are established in advance.

Step 3: Evaluating study quality
Assessing study quality is essential at every stage of Ecotone's review. When formulating questions (Step 1) and setting selection criteria (Step 2), a minimum acceptable level of design is defined based on the particular topic being explored.

Step 4: Summarizing the evidence
Data synthesis involves creating a library of study characteristics, study quality, and effect sizes (as applicable).

Step 5: Interpreting the findings
Based on the appropriateness of the study, findings are reviewed for their level of evidence and the extent the findings can be linked to other studies (or if they run counter to other studies' findings). Potential publication bias and other related biases are examined.

Levels of Evidence Used

To assess the strength of a causal study, Ecotone uses 7 levels of evidence of causality to rank what approach a study used to estimate causality. A stronger study uses a form of randomized controlled trials - RCTs - (such as what is used in drug trials) or a meta-analysis of RCTs. These use a randomized experimental approach to isolate a causal relationship and measure the scale of that relationship. Weaker levels of evidence do not use randomization but may still try to control various influencing factors to identify a causal relationship.

Wherever possible, Ecotone relies on studies that have a higher level of evidence of causality when making impact estimations. Other studies however can still be helpful to gain an understanding of what has been studied, where causality is suggestive but uncertain in scale, and if there are studies that find refuting evidence.

When Ecotone is reviewing resources for both causal and non-causal statements, other factors beyond just level of evidence are utilized to determine the reputability of the source. This includes credentials of the authors, whether a peer-review process took place, publishing institution and/ or funders of the analysis, acknowledgement of potentially differing results in other resources, and date of publication. If the resource is several years old or if there is a clear bias in figures shared for example, Ecotone will look for an alternative resource to use.

Levels of Evidence of Causality

(1 is highest, 7 is lowest)

1. Evidence from a systematic review or meta-analysis of all relevant RCTs (randomized controlled trial) or evidence-based clinical practice guidelines based on systematic reviews of RCTs or three or more RCTs of good quality that have similar results.
2. Evidence obtained from at least one well-designed RCT (e.g. large multi-site RCT).
3. Evidence obtained from well-designed controlled trials without randomization (i.e. quasi-experimental).
4. Evidence from well-designed case-control or cohort studies.
5. Evidence from systematic reviews of descriptive and qualitative studies (meta-synthesis).
6. Evidence from a single descriptive or qualitative study.
7. Evidence from the opinion of authorities and/or reports of expert committees. This category also contains statistics that make no causal claims.

B. Estimation Process

Estimating the impacts of SERI's certification process involved a multi-step process as has been partially described in the body of this document. The first step, the scoping process, involved understanding the R2 certification process, how it compares to other approaches in the electronics processing industry, and identifying the key differentiators between certified, uncertified, and informal processing pathways. This was paired with Ecotone's review of secondary research, exploring available evidence on used electronics processing and the impacts of formalization and certification, and the effects of certified used electronics management on health, GHG emissions reduction, data security, among others.

Over 100 resources were reviewed for this analysis. However, not all of them provided figures that were directly incorporated into the monetized outcome estimations, as the quality of an impact estimation relies on the strength of the causal linkage between what SERI's R2 certification entails and any given outcome. Thus, some resources were incorporated into the non-monetized outcomes evidence, providing support that an outcome is likely to be experienced, but may not be monetizable at this time.

To assess the strength of a causal study, Ecotone uses 7 levels of evidence of causality (listed on the bibliography section) to rank what approach a study used to estimate causality. A stronger study uses a form of randomized controlled trials - RCTs - (such as what is used in drug trials) or a meta-analysis of RCTs. These use a randomized experimental approach to isolate a causal relationship and measure the scale of that relationship. Weaker levels of evidence do not use randomization but may still try to control various influencing factors to identify a causal relationship. Wherever possible, Ecotone relies on studies that have a higher level of evidence of causality when making impact estimations. Other studies however can still be helpful to gain an understanding of what has been studied, where causality is suggestive, and if there are studies that find refuting evidence.

When Ecotone is reviewing resources for non-causal statements (e.g. GHG emissions avoided from reusing mobile phones), other factors are utilized to determine the reputability of the source. This includes credentials of the authors, whether a peer-review process took place, publishing institutions and/or funders of the analysis, acknowledgement of potentially differing results in other resources, and

date of publication. If the resource is several years old or if there is a clear bias in figures shared for example, Ecotone will look for an alternative resource to use.

As the intention of this analysis was to monetize the impacts of the R2 certification, a couple key methods were utilized, in alignment with cost-benefit analysis best practices. The monetization process combined market price and benefits transfer methods. Ecotone assigned dollar values to specific impacts either by using the direct market price associated with that impact (e.g., healthcare costs) or by applying estimates from existing studies that closely align with the features of SERI's R2 Certification. For instance, the healthcare and social costs of lead poisoning have been previously estimated in the context of residential lead exposure from paint. Rather than replicate that analysis, this study used available data on average blood lead levels among workers in used electronics recycling facilities and applied the existing cost estimates to quantify the portion of those costs avoided due to improved practices under the R2 Standard.

The monetization estimation generally follows the structure of:

# of units * effect of the R2 certification on a given variable * the cost/value of that variable.

B. Estimation Process

When it was not possible to reach a monetized estimate of value created, evidence was still reviewed to determine if a quantified estimate would be feasible. In some cases, the quality of evidence did allow for quantification of impacts. This estimation follows the same process as monetized estimates but generally requires fewer linkages.

The quantification estimation generally follows the structure of:

# of units * effect of the R2 certification on a given variable

Ecotone's analyses are conservative estimations, ensuring impact is not overstated. As monetization of outcomes is occurring, Ecotone's process utilizes trumping rules - best practice for benefit-cost analyses (as detailed by WSIPP, 2019). This means that where multiple outcome pathways lead to the same category of outcome (e.g. improved health outcomes for workers driven by reduced exposure to different heavy metals commonly found in used electronic devices such as lead, mercury, cadmium, arsenic, among others), Ecotone utilizes only the largest pathway or the pathway with the strongest casual understanding in the monetization or quantification process. This is to avoid risk of double counting gains made and to be sure not to overclaim impact generated. With future research, this approach may be shown to be too conservative.

The following are the core assumptions.

Additional assumptions are built into the individual outcome estimates. Please review the outcome estimation rate cards on the following section for details on specific assumptions and variables used for each outcome.

Counterfactual: This analysis is assumed to be in comparison to informal or formal but uncertified used electronics management.

Characteristics of Stakeholders: Primary stakeholders included in the outcome estimations include SERI facilities' workers and their households (two adults and 2 children), all with average health status, education, and income levels. Other stakeholders include local communities and global society.

SERI Data: Volume of used electronics processed by facilities and number of employees per country are annual values for 2024 and come from SERI's 2025 survey.

Time period of analysis: The outcome projections estimates are based on a 1 year period - 2024.

Duration of impact: Different benefits of R2 certification have a different projected duration based on the type of benefit and who is receiving the value. For example, health outcomes affect lifetime earnings - thus this benefit is projected over the expected working life of the child. We assume the benefits last a lifetime, provided there are no other health threats—such as lead exposure from alternative sources—that could offset these gains.

Multi-year benefits are discounted to a present value: This allows for direct comparison between investments today and benefits realized in future years, in alignment with cost-benefit analysis best practices.

C. Additional Survey Results

Table 30. Data sanitization per region

	Logic Data Sanitiz: Units sent to R2 DSV	Logic Data Sanitiz: Units sent to nonR2 DSV	Logic Data Sanitiz: Reuse in-house UNIT	Phys Data Sanitz: Sent to nonR2 WT	Phys Data Sanitz: Sent to R2 WT	Phys Data Sanitz: In-house WT
[redacted]						
Asia	26,323	23,973	4,558,075	221,477	14,609	3,531,359
Europe	200	-	1,296,634	2,546,826	940,839	1,602,604
North America	2,526,928	112,406	54,759,998	1,982,885	12,287,039	81,957,105
Oceania	358,717	-	649,671	26,762	475,971	1,412,825
South America	-	-	144,742	10	-	5,096,092
[redacted]						

Note: Weight is measured in kg.

Regional data was redacted for confidentiality purposes.

Table 31. Volume of devices processed (in KG) for testing and repair per region

TEST & REPAIR								
Type of device	Africa	Asia	Europe	North America	Oceania	South America	#N/A	Grand Total
Mobile Phones WT	[redacted]	-	-	45,110	-	-	[redacted]	[redacted]
Cameras WT	[redacted]	-	-	26	-	-	[redacted]	[redacted]
Cathode Ray Tube Monit WT	[redacted]	-	-	-	-	-	[redacted]	[redacted]
Cathode Ray Tube TVs WT	[redacted]	-	-	41,669	-	-	[redacted]	[redacted]
Desktop PCs WT	[redacted]	22,680	-	343,894	-	-	[redacted]	[redacted]
Flat-Panel Disp Monit WT	[redacted]	5,120	-	24,405	-	-	[redacted]	[redacted]
Flat-Panel Display TVs WT	[redacted]	298	-	34,832	-	-	[redacted]	[redacted]
Game Consoles WT	[redacted]	-	-	360	-	-	[redacted]	[redacted]
Harvested comp electr WT	[redacted]	8,863	-	591,857	-	-	[redacted]	[redacted]
House Monit&Cntrl Equi WT	[redacted]	-	-	-	-	-	[redacted]	[redacted]
Household Med equip WT	[redacted]	-	-	-	-	-	[redacted]	[redacted]
Laptops WT	[redacted]	19,316	-	144,424	-	-	[redacted]	[redacted]
Mixed CRTs(monit&TVs) WT	[redacted]	-	-	-	-	-	[redacted]	[redacted]
Music Instr, Rad, Hi-F WT	[redacted]	-	-	-	-	-	[redacted]	[redacted]
Mxd flat-panel displ WT	[redacted]	-	-	172,526	-	-	[redacted]	[redacted]
Oth telecom equip WT	[redacted]	-	-	48,569	-	-	[redacted]	[redacted]
Oth whole electr not WT	[redacted]	967	-	277,684	-	-	[redacted]	[redacted]
Photovoltaic Panels WT	[redacted]	-	-	-	-	-	[redacted]	[redacted]
Portable Audio & Video WT	[redacted]	-	-	10,068	-	-	[redacted]	[redacted]
Printers WT	[redacted]	28,648	-	-	-	-	[redacted]	[redacted]
Prof Monit&Cntrl Equip WT	[redacted]	-	-	160	-	-	[redacted]	[redacted]
Professional IT equip WT	[redacted]	538	-	1,952,569	-	-	[redacted]	[redacted]
Professional Med equip WT	[redacted]	-	-	-	-	-	[redacted]	[redacted]
Professional telecomm WT	[redacted]	-	-	23	-	-	[redacted]	[redacted]
Small Consumer Electr WT	[redacted]	-	-	79,803	-	-	[redacted]	[redacted]
Small IT equipment WT	[redacted]	6,152	-	216,294	-	-	[redacted]	[redacted]
Speakers WT	[redacted]	199	-	-	-	-	[redacted]	[redacted]
Video WT	[redacted]	-	-	-	-	-	[redacted]	[redacted]

Regional data was redacted for confidentiality purposes.

Table 32. Quantity of devices processed (in units) for reuse per region

REUSE								
Type of device	Africa	Asia	Europe	North America	Oceania	South America	#N/A	Grand Total
Cameras UNIT	[redacted]	5,476	132	235,964	299	235	-	[redacted]
Cathode Ray Tube Monitors UNIT	[redacted]	-	-	6,907	37	-	-	[redacted]
Cathode Ray Tube TVs UNIT	[redacted]	-	75	263	-	-	-	[redacted]
Desktop PCs UNIT	[redacted]	280,100	224,598	2,648,634	210,433	43,786	8,195	[redacted]
Flat-Panel Display Monito UNIT	[redacted]	166,428	119,919	770,602	163,776	83,125	2,291	[redacted]
Flat-Panel Display TVs UNIT	[redacted]	1,706	22,355	136,759	448	71	267	[redacted]
Game Consoles UNIT	[redacted]	16,134	154	187,498	-	-	61	[redacted]
Harvested Comp of elecr UNIT	[redacted]	10,283,145	2,425,152	14,430,954	106,085	31,660	613	[redacted]
Househ Monit&Cntrl equip UNIT	[redacted]	-	24	575,064	-	-	-	[redacted]
Household Medical equip UNIT	[redacted]	450	-	15,815	-	-	-	[redacted]
Laptops UNIT	[redacted]	1,561,049	1,198,784	9,329,396	505,188	92,453	31,368	[redacted]
Mobile Phones UNIT	[redacted]	4,791,309	87,075	39,297,023	42,893	3,702	339,643	[redacted]
Music Instr, Radio, Hi-Fi UNIT	[redacted]	3,343	-	8,462	-	91	-	[redacted]
Oth whole electr not list UNIT	[redacted]	1,785,218	406,116	1,505,312	-	1,131	5,448	[redacted]
Other telecomm equ UNIT	[redacted]	215,639	8,804	4,765,599	16,509	1,867	227	[redacted]
Photovoltaic Panels UNIT	[redacted]	-	-	10,076	-	-	27	[redacted]
Portable Audio & Video UNIT	[redacted]	682	721	133,634	-	126	-	[redacted]
Printers UNIT	[redacted]	15,840	4,328	232,671	21,599	2,898	251	[redacted]
Prof Monit& Cont equip UNIT	[redacted]	-	-	15,308	-	-	-	[redacted]
Professional IT equip UNIT	[redacted]	540,102	307,895	1,274,909	70,357	20,421	3,463	[redacted]
Professional Medical equi UNIT	[redacted]	10	-	13,276	-	-	-	[redacted]
Professional telecom equi UNIT	[redacted]	1,028	399,285	100,750	5,371	390	-	[redacted]
Small Consumer Electronic UNIT	[redacted]	17,145	22,322	6,958,406	72,370	6,540	5	[redacted]
Small IT equipment UNIT	[redacted]	854,010	652,964	7,901,508	136,490	23,040	9,256	[redacted]
Speakers UNIT	[redacted]	10,027	501	201,893	45	59	23	[redacted]
Video UNIT	[redacted]	715	133	361,362	557	199	35,755	[redacted]

Regional data was redacted for confidentiality purposes.

Table 33. Volume of devices processed (in KG) for recycling per region

RECYCLING								
Type of device	Africa	Asia	Europe	North America	Oceania	South America	#N/A	Grand Total
Cameras WT	[redacted]	5,433	25,380	17,123	1,779	1,263	-	[redacted]
Cathode Ray Tube Monit WT	[redacted]	743,166	22	51,945	-	6,405	335	[redacted]
Cathode Ray Tube TVs WT	[redacted]	907	12,471	1,733,525	-	1,262	199	[redacted]
Com/scrap:PrintCircBrd WT	[redacted]	6,186,177	200,370	30,294,333	-	147,412	-	[redacted]
Comm/scrap: Batteries WT	[redacted]	4,878,319	401,364	15,282,153	46,561	2,006,321	1,307	[redacted]
Comm/scrap: CRT glass WT	[redacted]	-	-	9,103,264	-	5,870,210	-	[redacted]
Comm/scrap: Ferrous WT	[redacted]	47,777,699	5,431,110	84,121,826	3,756,189	2,137,292	-	[redacted]
Comm/scrap: Copper WT	[redacted]	2,965,733	278,127	8,522,372	142,470	77,639	-	[redacted]
Comm/scrap: Flat-glass WT	[redacted]	120,154	4,003	1,478,697	-	23,178	5,998	[redacted]
Comm/scrap: Glass-oth WT	[redacted]	832,386	171	1,433,860	-	33,418	362	[redacted]
Comm/scrap: Metals-oth WT	[redacted]	8,825,086	637,142	40,227,634	6,963	189,207	9	[redacted]
Commod/scrap: Plastics WT	[redacted]	13,945,682	1,563,424	43,548,207	211,135	508,183	2,190	[redacted]
Commodities/scrap: Oth WT	[redacted]	20,634,120	2,552,683	22,364,195	164,080	1,379,736	-	[redacted]
Commodities/scrap:Alum WT	[redacted]	6,693,467	1,766,403	11,004,933	92,233	120,788	-	[redacted]
Compon remove for recycl	[redacted]	157,606	770,586	5,501,633	208,049	179,291	200	[redacted]
Desktop PCs WT	[redacted]	358,441	930,255	2,120,840	35,108	31,446	17,799	[redacted]
Flat-Panel Display Mon WT	[redacted]	458,132	250,868	20,843,333	6,051	47,700	34,521	[redacted]
Flat-Panel Display TVs WT	[redacted]	166,439	199,064	8,143,626	-	619	220	[redacted]
Game Consoles WT	[redacted]	97	700	18,814	-	-	57	[redacted]
Household Med equip WT	[redacted]	10	-	52,501	-	-	-	[redacted]
Household Monit&Cntrl WT	[redacted]	323	78	52,998	-	1	101	[redacted]
Laptops WT	[redacted]	538,791	84,156	1,583,197	5,777	20,328	16,357	[redacted]
Mobile Phones WT	[redacted]	518,798	10,321	121,334	58	1,730	60	[redacted]
Music Instr, Rad, HiFi WT	[redacted]	-	2,671	26,658	29	313	60	[redacted]
Mxd CRTs (monit&TVs) WT	[redacted]	497,191	-	852,878	13,927	300	-	[redacted]
Mxd flat-panel disp WT	[redacted]	66,299	229,327	3,889,394	284,867	10,620	-	[redacted]
Oth whole electr WT	[redacted]	112,515	2,237,507	3,691,222	-	274,434	263	[redacted]
Other telecom equip WT	[redacted]	113,657	9,295	791,572	427	2,196	553	[redacted]
Photovoltaic Panels WT	[redacted]	12,357	13,660	807,800	-	37,226	-	[redacted]
Portable Audio & Video WT	[redacted]	28,122	10,179	76,198	-	52	-	[redacted]
Printers WT	[redacted]	1,010,764	87,297	1,795,881	1,074	22,792	3,190	[redacted]
Prof Monit&Cntrl Equip WT	[redacted]	3,485	-	145,804	-	-	-	[redacted]
Prof telecom equip WT	[redacted]	542,531	6,187	454,039	-	596	45,485	[redacted]
Professional IT equip WT	[redacted]	481,523	3,581,109	2,911,251	27,126	187,012	387,054	[redacted]
Professional Med equip WT	[redacted]	20,731	-	328,574	-	-	-	[redacted]
Small Consumer Electr WT	[redacted]	85,654	20,180	1,819,611	30	997	491	[redacted]
Small IT equipment WT	[redacted]	1,371,223	1,009,875	1,953,018	87,453	78,141	667	[redacted]
Speakers WT	[redacted]	28,533	1,284	802,469	43	47	-	[redacted]
Video WT	-	2,171	14	1,055,203	28	75	2,266	1,059,757

Regional data was redacted for confidentiality purposes.

Table 34. Percentage of employees facing barriers to work per region

	% of employees facing barriers to work
Africa	[redacted]
Asia	149
Europe	26
North America	2154
Oceania	[redacted]
South America	[redacted]
Grand Total	

Note: There are indications that this question may have been misinterpreted, with some facilities possibly reporting raw numbers while others reported percentages.

Regional data was redacted for confidentiality purposes.

Impact Projections

A. Quantified and monetized outcomes

B. Scenarios for GHG emissions reductions

    I. Device reuse and recycling

    II. Commodities recycling

Impact Projections

The following section details the results of the impact estimations made. For details on the estimation process, specific resources used, and assumptions leveraged, please see the appendices of this report.

This analysis is an estimation, it is not a measurement of impact realized. The values included in this analysis are based on existing evidence, but their valuation is projected. The actual benefits generated may vary by the specific contexts of the facilities, their employees, and what electronics they are processing.

6.1 Quantified and Monetized Outcomes

These outcomes are the estimated benefits generated as a result of SERI's R2 certification process. The first column indicates the region, where applicable, for which the outcome was monetized or quantified. The second column describes the type of counterfactual scenario used in the estimation. The final two columns present the projected benefits at both the individual and regional levels. Where possible, regional estimates were derived by aggregating individual-level figures based on the number of R2 facility employees in each region.

The benefits of R2 certification are tied most closely to the avoided GHG emissions due to the reuse of mobile phones and laptops, followed by avoided loss of lifetime earnings due to elevated blood lead levels affecting children's IQ.

Table 12.

Outcomes estimated for Workers				
Region	Comparison	Outcomes	Projected benefits	
			Individual	Regional
Asia	Certified vs. informal The research conducted in Iran assessed lead exposure on workers from informal used electronics recycling workshops.	Reduced number of cancer cases	-	**32,540**
South America	Certified vs. informal The aim of the research conducted in Uruguay was to examine lead exposure in blood lead levels (BLLs) in low-income children exposed to lead through burning cables.	Reduced number of cancer cases	-	**237**
Africa	Certified vs. formal but uncertified The study is conducted in recycling factories, which we can assume are formal places.	Reduced number of cancer cases		
South America	Certified vs. informal The aim of the research conducted in Uruguay was to examine lead exposure in blood lead levels (BLLs) in low-income children exposed to lead through burning cables.	Avoided healthcare costs due to reduced likelihood of developing cancer	**$3**	**$1,877**

Regional data was redacted for confidentiality purposes.

The benefits of R2 certification are tied most closely to the avoided GHG emissions due to the reuse of mobile phones and laptops, followed by avoided loss of lifetime earnings due to elevated blood lead levels affecting children's IQ.

Table 13.

Outcomes estimated for Workers and Local Communities				
Region	Comparison	Outcomes	Projected benefits	
			Individual	Regional
Global	Certified vs. Formal but uncertified	Potential increase in number of jobs from refurbishing/repair vs. recycling alone (**assuming 10% additional reuse rate** for R2 facilities)	**-**	**63 jobs**
North America	Certified vs. Formal but uncertified	Avoided workplace injury or illness due to ISO4 5001 certification (required as a part of R2)	**$240**	**$4,768,320**
North America	Certified vs. Formal but uncertified	Avoided illness and injury cases associated with job transfers or restrictions due to ISO 45001 certification (required as a part of R2) - *a subset of the above outcome*	**$122**	**$2,431,843**
North America	N/A	Improved access to smartphones due to donations to low-income communities (per donated smartphone)	**$437**	**-**

The benefits of R2 certification are tied most closely to the avoided GHG emissions due to the reuse of mobile phones and laptops, followed by avoided loss of lifetime earnings due to elevated blood lead levels affecting children's IQ.

Table 14.

Outcomes estimated for the Children of Workers and Children in Local Communities				
Region	Comparison	Outcomes	Projected benefits	
			Individual	Regional
North America	Certified vs. formal but uncertified. The study is conducted in Puerto Rico, in the only known legal battery recycling smelter in the Caribbean.Therefore, we can assume that the facility is formal but uncertified.	Avoided healthcare costs of high BLL in children	**$11**	**$424,460**
North America	Certified vs. formal but uncertified. The study is conducted in Puerto Rico, in the only known legal battery recycling smelter in the Caribbean.Therefore, we can assume that the facility is formal but uncertified.	Avoided loss of lifetime earnings due to high BLL and reduced IQ	**$539**	**$21,423,942**
North America	Certified vs. formal but uncertified. The study is conducted in Puerto Rico, in the only known legal battery recycling smelter in the Caribbean.Therefore, we can assume that the facility is formal but uncertified.	Avoided healthcare costs of ADHD treatment due to high BLL in children	**$11**	**$445,706**
North America	Certified vs. formal but uncertified. The study is conducted in Puerto Rico, in the only known legal battery recycling smelter in the Caribbean.Therefore, we can assume that the facility is formal but uncertified.	Avoided costs of future criminal activity	**$1**	**$44,367**
North America	N/A	Increase in lifetime income due to higher likelihood of high school graduation from donated laptop	**$3,750**	**-**

The benefits of R2 certification are tied most closely to the avoided GHG emissions due to the reuse of mobile phones and laptops, followed by avoided loss of lifetime earnings due to elevated blood lead levels affecting children's IQ.

Table 15.

GHG Emission savings from Increased Reuse of Devices				
Region	Comparison	Outcomes	Projected benefits	
			Per Device	Global
Global	Certified vs. formal but uncertified Assuming **10 percentage point additional rate of reuse**	Total Estimated value of GHG emissions avoided from additional *Mobile Phones* reused by R2 facilities compared to formal but uncertified facilities	$0.56	$29,836,420
Global		Total Estimated value of GHG emissions avoided from additional *Laptops* reused by R2 facilities compared to formal but uncertified facilities	$2.80	$40,655,720
Global		Total Estimated value of GHG emissions avoided from additional *Flat Panel Monitors* reused by R2 facilities compared to formal but uncertified facilities	$1.37	$1,792,628
Global		Total Estimated value of GHG emissions avoided from additional *Laptop Batteries* reused by R2 facilities compared to formal but uncertified facilities	$0.04	Battery count is uncertain
Global		Total Estimated value of GHG emissions avoided from additional *Hard Drives* reused by R2 facilities compared to formal but uncertified facilities	$0.13	Hard Drive size is not tracked

The benefits of R2 certification are tied most closely to the avoided GHG emissions due to the reuse of mobile phones and laptops, followed by avoided loss of lifetime earnings due to elevated blood lead levels affecting children's IQ.

Table 16.

GHG Emission savings from Increased Recycling of Devices				
Region	Comparison	Outcomes	Projected benefits	
			Per Device	Global
Global	Certified vs. formal but uncertified Assuming **10 percentage point additional rate of recycling**	Total Estimated value of GHG emissions avoided from additional *Mobile Phones* recycled by R2 facilities compared to formal but uncertified facilities	$0.003	$30,337
Global		Total Estimated value of GHG emissions avoided from additional *Laptops* recycled by R2 facilities compared to formal but uncertified facilities	$0.03	$49,560
Global		Total Estimated value of GHG emissions avoided from additional *Flat Panel Monitors* recycled by R2 facilities compared to formal but uncertified facilities	$0.08	$117,953
Global		Total Estimated value of GHG emissions avoided from additional *CRTs* recycled by R2 facilities compared to formal but uncertified facilities	$0.28	$24,901
Global		Total Estimated value of GHG emissions avoided from additional *Laptop Batteries* recycled by R2 facilities compared to formal but uncertified facilities	$0.04	N/A
Global		Total Estimated value of GHG emissions avoided from additional *Mobile Phone Batteries* recycled by R2 facilities compared to formal but uncertified facilities	$0.01	N/A

6.2 Scenarios for Greenhouse Gas (GHG) Emissions Reductions

Estimating the GHG benefits of R2 certification was based around 1) the GHG benefit from reuse or recycling of devices and 2) the likely increase in rates of reuse and recycling compared to what would otherwise occur. This second component is due to the standards included in R2 that require processes that prioritize reuse and recycling over landfilling to an extent beyond what might otherwise occur. There is however uncertainty around how much more likely an R2 facility is to reuse/recycle compared to a Non-R2 facility. This type of measurement has not been conducted. However, based on known market conditions and the intentional impact baked into the design of the R2 standards it is very likely that across most devices there is at least some additional reuse/recycling. Increased rates of reuse and recycling are assumed to range from a small boost of 5 percentage points to a very large boost of 40 percentage points. In all likelihood, the medium scenario of a 10 percentage point boost in reuse/recycling is a conservative benchmark to point to, particularly when comparing against formal facilities.

6.2.1 Device Reuse and Recycling

The following tables detail the estimated kilograms of greenhouse gas emissions avoided for select devices/commodities, communicated as carbon dioxide equivalents (CO2e), as well as the social cost of carbon that is avoided thanks to having avoided those emissions. See **Appendix G** for details on what the social cost of carbon entails. See **Appendix F** for details on the avoided carbon emissions per device that is reused or recycled.

It is assumed that devices being reused and recycled would otherwise have been landfilled and would be replaced by a newly manufactured device using virgin materials.

It is quickly apparent as well that the following tables show only a handful of the types of electronics processed by R2 facilities. The devices included in this analysis were selected because they had sufficient data and were some of the most common devices processed. Other electronics such as batteries and hard drives are considered to be highly impactful but they are not currently tracked by R2 facilities by the specific type of battery or hard drive (e.g. laptop battery vs. cell phone battery; enterprise 3.5" hard drive vs. SSD). As data on these devices is collected, estimations of the total benefits of R2 facilities can be expanded. As a result, the figures shown here should be considered preliminary and not encompassing all that R2 facilities achieve. The GHG benefits in total are likely to be much greater than the sampling of figures included here.

Greenhouse Gas emissions avoided from additional reuse and recycling due to R2 certification

Table 19. Reuse of laptops has the largest greenhouse gas impact amongst those devices analyzed for reuse

	Estimated Kg CO_2e saved in 2024 from additional rates of reuse by R2 facilities relative to Non-R2 facilities			
Increased rate of reuse	5 percentage point	10 percentage point	20 percentage point	40 percentage point
Mobile Phones	89,123,316	178,246,632	356,493,264	712,986,528
Laptops	127,209,810	254,419,620	508,839,240	1,017,678,480
Flat-Panel Display Monitor (24")	6,402,242	12,804,484	25,608,968	51,217,936

If we assume a 10 percentage point increase in the number of mobile phones processed by R2 facilities compared to if those phones would have gone to non-R2 facilities, there is an estimated 178 million *additional* kg of GHG avoided in 2024.

Table 20. Recycling Flat Panel Display Monitors has the largest greenhouse gas impact amongst those devices analyzed for recycling

	Estimated Kg CO_2e saved from additional rates of recycling by R2 facilities relative to Non-R2 facilities			
Increased rate of recycling	5 percentage point	10 percentage point	20 percentage point	40 percentage point
Mobile Phones	104,612	209,224	418,448	836,896
Laptops	170,897	341,795	683,589	1,367,178
Flat-Panel Display Monitor (24")	406,733	813,466	1,626,932	3,253,864
CRTs (15-23 kg set)	85,866	171,732	343,465	686,929

Social cost of carbon avoided from additional reuse and recycling due to R2 certification

Table 21. Social cost of carbon avoided from increased rates of reuse is likely over $60 million in 2024

	Estimated Social Cost of Carbon saved from additional rates of reuse by R2 facilities relative to Non-R2 facilities			
Increased rate of reuse	5 percentage point	10 percentage point	20 percentage point	40 percentage point
Mobile Phones	$12,922,881	$25,845,762	$51,691,523	$103,383,047
Laptops	$18,445,422	$36,890,845	$73,781,690	$147,563,380
Flat-Panel Display Monitor (24")	$928,325	$1,856,650	$3,713,300	$7,426,601

Table 22. Social cost of carbon avoided from increased rates of recycling is likely over $200,000 in 2024

	Estimated Social Cost of Carbon saved from additional rates of recycling by R2 facilities relative to Non-R2 facilities			
Increased rate of recycling	5 percentage point	10 percentage point	20 percentage point	40 percentage point
Mobile Phones	$15,169	$30,337	$60,675	$121,350
Laptops	$24,780	$49,560	$99,120	$198,241
Flat-Panel Display Monitor (24")	$58,976	$117,953	$235,905	$471,810
CRTs (15-23 kg set)	$12,451	$24,901	$49,802	$99,605

The social cost of carbon avoided tends to be higher for devices that are reused rather than recycled. This is because more energy and virgin materials are being avoided when a device can be reused. For R2 facilities as a whole, the impact is estimated to be much greater for reuse rather than recycling as well. In some cases, R2 facilities generate 100x the GHG savings due to their greater rates of reuse compared to non-R2 facilities. This is not to say recycling is not impactful, but just to note that the benefits per reused device paired with the volume of devices processed means that cumulatively, the benefit of R2 certification is likely to be more significant from additional rates of reuse rather than additional rates of recycling.

The following tables shows the regional breakdown of the avoided CO2e and social cost of carbon avoided thanks to a 10 percentage point increase in rates of reuse and recycling. The figures generally reflect the varying scale of activities in each region. Across both reuse and recycling the CO2e benefits are greatest in North America, where a majority of R2 certified facilities are based.

Reuse benefits tend to be greatest for mobile phones and laptops given the very large volume of those devices that are processed by R2 facilities. However, in the case of recycling, the CO2e benefit of recycling Flat-Panel Display Monitors is greater than mobile phones and laptops, due in part to the larger per unit benefit from recycling the monitors.

Greenhouse Gas emission reductions by region from additional reuse and recycling at R2 facilities compared to non-R2 facilities

Table 23. North America has the largest greenhouse gas impact from reuse due to the scale of devices processed, followed by Asia

	At Scale - Kg CO2e saved from 10 percentage point increase in reuse by R2 facilities							
	Africa	Asia (Total)	India (sub-set of Asia)	China (sub-set of Asia)	Europe	North America	Oceania	South America
Mobile Phones	[redacted]	19,165,236	100,336	12,852,908	348,300	157,188,092	171,572	14,808
Laptops	[redacted]	31,220,980	4,723,940	3,391,440	23,975,680	186,587,920	10,103,760	1,849,060
Flat-Panel Display Monitor (24")	[redacted]	1,630,994	271,793	249,753	1,175,206	7,551,900	1,605,005	814,625

Table 24. North America has the largest greenhouse gas impact from recycling, followed by Asia

	At Scale - Kg CO2e saved from 10 percentage point increase in rate of recycling by R2 facilities							
	Africa	Asia (Total)	India (sub-set of Asia)	China (sub-set of Asia)	Europe	North America	Oceania	South America
Mobile Phones	[redacted]	155,639	150,151	0	3,096	36,400	17	519
Laptops	[redacted]	75,830	66,253	83	11,844	222,820	813	2,861
Flat-Panel Display Monitor (24")	[redacted]	17,164	8,880	0	9,399	780,915	227	1,787
CRTs (15-23 kg set)	[redacted]	64,261	63,267	0	1,079	154,200	0	662

Regional data was redacted for confidentiality purposes.

Social cost of carbon avoided by region from additional reuse and recycling at R2 facilities compared to non-R2 facilities

Table 25. The greatest social costs of carbon are avoided in North America due to the volume of devices processed there

	At Scale - Social Cost of Carbon saved from 10 percentage point increase in reuse by R2 facilities							
	Africa	Asia (Total)	India (sub-set of Asia)	China (sub-set of Asia)	Europe	North America	Oceania	South America
Mobile Phones	[redacted]	$2,778,959	$14,549	$1,863,672	$50,504	$22,792,273	$24,878	$2,147
Laptops	[redacted]	$4,527,042	$684,971	$491,759	$3,476,474	$27,055,248	$1,465,045	$268,114
Flat-Panel Display Monitor (24")	[redacted]	$236,494	$39,410	$36,214	$170,405	$1,095,025	$232,726	$118,121

Table 26. The greatest social costs of carbon are avoided in North America due to the volume of devices processed there

	At Scale - Social Cost of Carbon saved from 10 percentage point increase in rate of recycling by R2 facilities							
	Africa	Asia (Total)	India (sub-set of Asia)	China (sub-set of Asia)	Europe	North America	Oceania	South America
Mobile Phones	[redacted]	$22,568	$21,772	$0	$449	$5,278	$3	$75
Laptops	[redacted]	$10,995	$9,607	$12	$1,717	$32,309	$118	$415
Flat-Panel Display Monitor (24")	[redacted]	$2,489	$1,288	$0	$1,363	$113,233	$33	$259
CRTs (15-23 kg set)	[redacted]	$9,318	$9,174	$0	$156	$22,359	$0	$96

Regional data was redacted for confidentiality purposes.

6.2.2 Commodities Recycling

R2 facilities process a range of commodities associated with electronic devices. The likelihood of an R2 facility recycling those commodities compared to non-R2 facilities is uncertain, but for certain commodities, the requirements of R2 make it so they are more likely to be recycled than if they had gone to a non-R2 certified facility. This is particularly true for those commodities with low economic value such as plastics.

The following tables provide a summary of the GHG benefits associated with recycling select commodities and the subset of those total benefits resulting from the higher rates of recycling realized by R2 facilities compared to non-R2 facilities. The tables show low, medium, and high scenarios for the additional rates of recycling due to R2 certification. Conservatively, the medium estimate is suitable for public communication as it asserts an only 10 percentage point increase in the rate of recycling. This figure may however not be appropriate for high value commodities such as printed circuit boards which have valuable metals that would be recycled to some extent by nearly all types of facilities, not just R2 certified facilities. The SERI team should determine the most appropriate rate of recycling to communicate for each commodity.

Total greenhouse gas emissions avoided and social costs of carbon avoided due to commodity recycling by R2 facilities

Table 27. Commodity recycling saves hundreds of millions of kilograms of carbon emissions

	Estimated GHG avoided from commodity recycling by all R2 facilities in 2024	
	Total Kg CO2e avoided - Conservative Lower Bound Estimate	Total $ saved from avoided CO2e emissions
Copper	35,959,023	$5,214,058
CRT glass	142,248,003	$20,625,960
Ferrous	171,868,939	$24,920,996
Plastics	89,668,232	$13,001,894
Aluminum	177,100,416	$25,679,560

While these are not all commodities recycled by R2 facilities, those shown above highlight prominent categories common to processing used electronics. CRT glass, Ferrous metals, and Aluminum are the largest sources of GHG emission savings due to their larger per unit GHG benefit as well as the greater volume of these commodities being processed by R2 facilities.

Greenhouse Gas emissions and social costs avoided from additional rates of commodity recycling due to R2 certification

Table 28. CRT Glass, Ferrous metals, and Aluminum have the potential to provide the greatest GHG savings

	Estimated GHG avoided (kg) from 5, 10, and 20 percentage point increases in rates of recycling relative to Non-R2 Facilities		
Increased rate of recycling	**Low** (5 percentage point)	**Medium** (10 percentage point)	**High** (20 percentage point)
Copper	1,797,951	3,595,902	10,787,707
CRT glass	7,112,400	14,224,800	28,449,601
Ferrous	8,593,447	17,186,894	51,560,682
Plastics	4,483,412	8,966,823	29,889,411
Aluminum	8,855,021	17,710,042	51,162,342

Table 29. Plastics, while not having the greatest GHG impact, may be among the commodities most affected by R2 certification

	Estimated Social Cost of Carbon Avoided from Increased rates of Recycling relative to Non-R2 Facilities		
Increased rate of recycling	**Low** (5 percentage point)	**Medium** (10 percentage point)	**High** (20 percentage point)
Copper	$260,703	$521,406	$1,564,218
CRT glass	$1,031,298	$2,062,596	$4,125,192
Ferrous	$1,246,050	$2,492,100	$7,476,299
Plastics	$650,095	$1,300,189	$4,333,965
Aluminum	$1,283,978	$2,567,956	$7,418,540

Measurement and Research Priorities

A. Key metrics

B. Evidence gaps and research recommendations

7.1 Key Metrics

Within the impact estimates there are several key metrics that drive the value generated by SERI's R2 certification. These are not necessarily metrics that R2 facilities track, but they are important variables for generating estimates. For those metrics that R2 facilities do not track, figures from the evidence base were leveraged.

Health Outcomes

- # of R2 facilities' employees
- Likelihood of death from cancer-related causes due to elevated blood lead levels (BLL)
- Average costs of per cancer patient
- Average costs of workplace injuries
- Percent reduction in illness and injury at the workplace due to different type of certifications
- Likelihood of children having elevated BLL due to parents bringing lead dust in working clothes
- Likelihood of high concentrations of lead in home dust (>40 ug/sq ft) leading to a BLL in children in that home higher than 10 ug/dL.
- Average cost of treating high BLL in children
- Average IQ point loss per µg/dL of lead in blood
- Likelihood of children developing ADHD due to elevated BLL
- Average cost of treating ADHD in children

Environmental Outcomes

- Volume of used electronics repaired for reuse purposes
- Proportion of devices that are reused due to certification
- # of devices processed by R2 facilities in 2024
- GHG emissions avoided due to reuse of devices (kg of CO2e)
- Social Cost of Carbon: USD per Kg
- Material recovery rates

Social Outcomes

- # of jobs created per tonne of used electronics repaired
- # of incidents of work-related injuries and illness in the waste industry per 100 FTEs
- # of used electronics donated to low-income communities
- Willingness to pay for access to smartphones
- Proportion of lead-linked burglaries per resident
- Average direct cost per burglary
- Likelihood of graduating from high school due to having access to a laptop
- Likelihood that increased educational attainment will increase future earnings
- USD increase in future income due to having high school diploma

7.2 Evidence Gaps and Research Recommendations

As has been noted, there were limitations to what outcomes could be projected for SERI's R2 certification due to various data gaps. Gaps can be tied to both the data collected by R2 facilities as well as lack of data in the literature reviewed. While numerous data gaps were identified as a part of this analysis, a few of them can be addressed by R2 facilities and partner organizations such as advocacy groups and academic institutions. With the reduction of these gaps, additional outcomes and more refined outcome estimates would be possible. Prominent gaps included:

1. **R2 facilities conditions:**
   a. Recommendation: R2 Certified facilities should begin collecting standardized data on key operational indicators, including the number of workplace injuries, the number and type of devices donated to low-income communities, and environmental metrics such as the concentration levels of lead and other hazardous substances within the facility. This information will improve the accuracy of impact assessments across health, social, and environmental outcomes.
2. **R2 facilities employees' demographics:**
   a. Recommendation: Facilities should collect demographic information on their workforce such as gender, race, household composition, socioeconomic status, and general health. Capturing this data will allow for more representative and equitable estimates of the benefits associated with R2 certification.
3. **Healthcare costs faced by R2 facilities' employees:**
   a. Recommendation: Where feasible, R2 facilities should collect anonymized data on healthcare costs related to occupational illness or exposure. This will enable more precise calculations of avoided health-related expenses and strengthen the evidence base for the certification worker health benefits.
4. **Environmental outcomes:** Facilities should consider enhancing tracking of environmental performance indicators such as rates of reuse and recycling compared to industry average benchmarks. This will support more robust quantification of the environmental impact of R2 practices and improve alignment with sustainability reporting standards.

More broadly, it is important for SERI to continue tracking the volume and types of used electronics processed by R2 certified facilities over time. As these facilities mature and scale, consistent long-term data collection will be critical to demonstrating the growing health, social, and environmental impacts of R2 certification.

Impact Analysis Recommendations

Strengthen Data Collection and Monitoring: SERI and R2 Certified facilities should continue tracking core operational metrics such as volumes processed, reuse rates, and workplace safety, while using periodic surveys to gather additional insights from staff.

Improve Evaluation and Evidence Generation: SERI should work with academic, public health, and environmental partners to address data gaps by studying outcomes related to workforce demographics, occupational health, environmental performance, and the economic and social impacts of device reuse and recycling. In addition, incorporating selected impact metrics into the certification process, such as injury rates, environmental compliance, and reuse volumes, would strengthen performance tracking and reinforce the value of R2 Certification.

Build Facility Capacity and Encourage Participation: SERI could support facilities by providing guidance, training, or technical assistance to help them collect data on environmental outcomes, worker health, and device reuse. This type of support would be especially useful for smaller or newly certified facilities. In addition, SERI should consider publishing aggregate impact data in public reports or dashboards to demonstrate the value of R2 Certification, build trust, and strengthen its leadership in responsible electronics management.

Impact Communication

A. Talking points on the impact of R2 certification

B. Non-monetized impacts of R2 certification

C. Literature insights

D. Communicate the relevant Sustainable Development Goals

8.1 Talking Points on the Impact of R2 Certification

The following talking points are used to highlight key takeaways from the previously detailed tables and to put those takeaways into narrative form.

Environmental Impact

- Greenhouse Gas Emissions Reduction: The largest benefit of the R2 certification that was estimated in this analysis is the reduction of GHG emissions from the reuse of electronics.
    - Amongst the devices analyzed, reusing laptops and mobile phones provides the greatest GHG savings thanks to the large volume of these devices that are processed. In total, an estimated $370 million and $270 million in social costs of carbon were avoided due to reusing laptops and mobile phones that otherwise would have been replaced by a newly manufacturing device.
    - Assuming a 10 percentage point higher rate of reuse at R2 facilities compared to Non-R2 facilities, the value of avoided GHG emissions is estimated at over $40 million for laptops and nearly $30 million for mobile phones.
    - Even a modest 5-percentage-point increase in reuse rates by R2 facilities results in significant GHG savings of $20 million and $15 million for laptops and mobile phones.

Converting the GHG Benefits of Mobile Phone Reuse

With a 10 percentage point increase in the number of mobile phones processed by R2 facilities compared to if those phones would have gone to non-R2 facilities, there is an estimated 178 million kg of GHG avoided. This translates into:

- About 454 million miles driven by the average gasoline car in the U.S.
- The electricity used over 1 year for about 37,000 single family homes.
- The carbon sequestered in 1 year by about 178,000 acres of forest in the U.S.

(EPA - Greenhouse Gas Equivalencies Calculator, 2024)

8.1 Talking Points on the Impact of R2 Certification

The following talking points are used to highlight key takeaways from the previously detailed tables and to put those takeaways into narrative form.

Health and Social Benefits

- Protecting Community Health: R2 certification helps prevent serious health issues associated with informal electronics recycling.
    - A significant projected benefit comes from avoiding lost lifetime earnings due to elevated blood lead levels in children, which can impact IQ. This is valued at over $21 million.
    - Certification leads to a reduction in cancer cases in regions like Asia and South America by minimizing exposure to lead and other toxins from informal e-waste processing.
- Improving Worker Safety: The ISO 45001 certification, a required part of R2, leads to safer workplaces.
    - This is projected to avoid over $4.7 million in costs related to workplace injuries and illnesses in North America.
- Job Creation: Refurbishing and repairing electronics creates significantly more jobs than landfilling or recycling alone.
    - R2 facilities are estimated to support 63 additional jobs through their higher rates of reuse and repair compared to if they had been non-certified facilities. For every 1,000 tonnes of used electronics processed, repairing them generates 200 jobs, compared to just 15 for recycling and sorting (Sampson, 2015).

Digital Inclusion

- Increasing Digital Inclusion: Refurbished electronics can be donated or sold at lower prices, which helps to bridge the digital divide for underserved populations.
    - Access to a donated laptop can increase a teenager's likelihood of graduating high school by 6 to 8 percentage points, boosting lifetime earnings by $3,750 per student on average.
    - Internet use among older adults can reduce depression by approximately 20-28%.
    - Related, access to smartphones is valued at, on average, over $430 per year in the U.S. (Brynjolffson et al., 2019), suggesting that providing free or low cost smartphones to low income populations can have significant value.

8.2 Non-monetized Impacts of R2 Certification

While many impacts of SERI's R2 certification can be quantified and monetized, there remain a number of outcomes that are currently not monetized due to either limitations in available data or the inherently intangible nature of the benefit. Nonetheless, these outcomes represent important dimensions of value created by R2 certified facilities and should be considered in any comprehensive impact assessment.

The following are key categories for non-monetized outcomes associated with the implementation of the R2 certification:

1. Reduced Risk of Data Breaches and Legal Liabilities
R2 certified facilities adhere to stringent data destruction protocols, significantly reducing the likelihood that sensitive data is improperly handled or leaked. This protects both individuals and organizations from identity theft, reputational damage, and costly legal or regulatory consequences.

2. Decreased Landfilling and Environmental Pollution
By diverting used electronics from landfills, certified facilities play a critical role in preventing the release of hazardous substances—including heavy metals and persistent organic pollutants—into soil, groundwater, and surrounding ecosystems.

3. Reduced Illegal Exports and Increased Resource Recovery
The R2 certification promotes legal and transparent downstream management of used electronics. This helps prevent devices from entering informal or unsafe processing streams, particularly in lower-income countries, and supports more efficient recovery of valuable components and critical raw materials.

4. Improved Consumer Trust and Brand Reputation
Certification signals a commitment to responsible electronics reuse and recycling, enhancing public trust in participating companies and brands. This reputational benefit can influence consumer behavior and strengthen engagement with electronics take-back and recycling programs.

5. Increased Digital Inclusion through Refurbished Devices
R2 certified facilities often refurbish devices for resale or donation, enabling affordable access to technology for underserved populations. This contributes to bridging the digital divide and expanding participation in the digital economy.

These non-monetized outcomes are essential to understanding the full value of SERI's R2 certification and underscore the broader social, environmental, and economic benefits that extend beyond direct financial metrics.

8.3 Literature Insights

Understanding the broader ecosystem of risks and opportunities surrounding used electronics processing is essential to contextualizing the value of R2 certification. To complement the analysis of facility-level and projected outcomes, this section summarizes key findings from the academic and grey literature on the environmental, social, economic, and behavioral impacts of used electronics waste.

This review draws on studies from leading organizations and peer-reviewed sources to document the consequences of improper disposal, the untapped potential of resource recovery, and the importance of consumer behavior, brand trust, and digital inclusion. Together, these insights help to articulate the full spectrum of challenges addressed by SERI's R2 certification and guide future areas for monitoring, advocacy, and programmatic innovation.

Reduced Risk of Data Breaches and Legal Liabilities

Improper disposal of used electronics poses significant and growing risks to data privacy and digital security. In an age where sensitive personal and organizational data is routinely stored on electronic devices, failure to adequately erase this information before resale or disposal can have severe consequences.

A large-scale study by the National Association for Information Destruction (NAID) found that **40%** of devices resold through public channels contained personally identifiable information (PII) [31] . A separate investigation by Stellar revealed that **71%** of devices in the second-hand market still held sensitive personal or business data. Alarmingly, only **29%** of users had taken any proper steps to erase data prior to disposal [81] . Memory cards (**98%**), hard drives (**46%**), and mobile phones (**60%**) were among the most vulnerable, often containing passport scans, financial records, contacts, and business documents [81] .

These lapses expose individuals to identity theft, fraud, and reputational harm—and expose organizations to legal penalties and operational risks. The average cost of a data breach in 2024 was USD **4.9 million**, and nearly half of all breaches involve PII [32]. As digital security regulations tighten worldwide, failure to manage used electronics waste securely is becoming a major liability.

R2 certification addresses these concerns directly by requiring certified facilities to implement secure, auditable data destruction protocols. This reduces the likelihood of breaches, safeguards consumer and institutional trust, and supports compliance with evolving data privacy legislation.

Note: Numbers in brackets refer to sources listed in the Bibliography section of the Appendix.

Decreased Landfilling and Environmental Pollution

The environmental consequences of landfilling or improperly processing used electronics are extensive and well-documented. In 2021, an estimated **57.4 million tonnes** of used electronics were discarded globally—an amount greater in weight than the Great Wall of China [95] . Without systemic change, that figure is projected to grow to **74 million tonnes** by 2030, driven by rapid device turnover and lack of collection infrastructure [95] .

Used electronics often contain hazardous substances such as mercury, brominated flame retardants (BFRs), cadmium, and lead. When landfilled or incinerated, these substances leach into soil and groundwater or are released into the atmosphere, threatening ecosystems and human health. Decomposition times are also extreme: plastic in electronics can persist for up to one million years, while metals like aluminum and copper can remain in the environment for centuries.

In the U.S. alone, **151 million phones** are landfilled or incinerated every year [22] . Meanwhile, the global externalized cost of used electronics mismanagement—including public health and environmental degradation—has been estimated at **$78 billion** annually [86] .

Beyond toxic exposure, informal recycling hubs such as Agbogbloshie in Ghana illustrate the socioeconomic burden of used electronics pollution. Approximately **40,000 people** live or work near the dump site, facing elevated risks of respiratory illness, neurological disorders, and even mortality [56] .

R2 certification prevents many of these harms by requiring rigorous environmental controls, transparent downstream vendor due diligence, and diversion of used electronics from unsafe disposal. It also contributes to pollution reduction not only through compliant handling but by enabling device reuse, repair, and responsible material recovery.

Note: Numbers in brackets refer to sources listed in the Bibliography section of the Appendix.

Reduced Illegal Exports and Increased Resource Recovery

Electronic devices are rich in recoverable materials—yet large volumes are lost to illegal exports and inefficient recycling each year. In 2022 alone, **5.1 billion** kg of used electronics waste were shipped across borders, with **3.3 billion** kg moving from high- to low- and middle-income countries through undocumented and uncontrolled channels [4] . These shipments often bypass environmental and labor protections, ending up in informal dumps or crude processing facilities.

The financial scale of this problem is staggering: illicit used electronics waste trade is valued at more than **$19 billion** annually, while the potential resource value embedded in electronics exceeds **$57 billion** [56] . For example, one ton of waste circuit boards can yield 143 kg of copper, 0.5 kg of gold, and significant amounts of silver, nickel, and tin [56] . In one million mobile phones alone, there is enough embedded metal to recover **24 kg** of gold and **16,000 kg** of copper [95] .

Recovering these materials through safe, certified channels is not only economically sound but also far less energy- and emissions-intensive than mining virgin resources. R2 certification combats illegal exports by requiring documentation, transparent tracking, and adherence to transboundary movement regulations. It also supports efficient recovery systems that retain material value within the circular economy.

Improved Consumer Trust and Brand Reputation

Consumers are critical actors in the electronics life cycle—yet most are unaware of how to dispose of their devices responsibly. Surveys across nine major markets found that although **80%** of people have heard of "used electronics," **33%** don't know what it means, and **18%** have never encountered the term [29] . In countries like the U.S. and UK, fewer than one-third of consumers can define it [29] .

Despite this, a significant share of users—**44%**—actively seek out places to recycle electronics, and **35%** prefer to sell back devices to companies or programs [29]. However, improper disposal persists: **30%** of people hold onto unused devices, while others discard them with trash or general recyclables [29].

Consumer trust is increasingly linked to sustainable business practices. Products with environmental, social, and governance (ESG) claims have outperformed the market, growing **28%** over five years, and sustainability-minded consumers are more likely to favor products with recycled materials, transparent sourcing, and take-back incentives [24].

R2 certification contributes to building this trust by offering an independent, verified assurance that used electronics will be handled responsibly.

Note: Numbers in brackets refer to sources listed in the Bibliography section of the Appendix.

Increased Digital Inclusion through Refurbished Devices

Access to digital technology is now a prerequisite for economic participation, civic engagement, education, and even mental health. Yet millions of people—especially in low-income, aging, or rural populations—lack affordable devices or digital literacy.

Refurbished electronics offer a pathway to bridge this divide. Research shows that basic digital skills can earn workers a **17%** wage premium [23], while internet use among older adults reduces depression rates by up to **28%** [17]. Digital access also improves health outcomes: people with greater internet use are more likely to seek health information, use government services, and remain socially connected [58].

Globally, the demand for affordable, functional devices far exceeds supply—particularly among schools, nonprofits, and low-income households. R2 certified facilities enable reuse by refurbishing devices for secondary markets or donation, while ensuring functionality, safety, and data protection.

This not only reduces used electronics waste, but also fosters digital equity—empowering individuals and communities to thrive in an increasingly connected world.

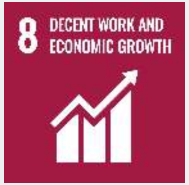
Note: Numbers in brackets refer to sources listed in the Bibliography section of the Appendix.

8.4 Communicate the Relevant Sustainable Development Goals

The United Nations Sustainable Development Goals (SDGs) are a set of 17 global goals adopted in 2015 as part of the 2030 Agenda for Sustainable Development. They provide a blueprint for addressing the world's most pressing challenges, including poverty, inequality, climate change, environmental degradation, peace, and justice. Governments, businesses, and communities worldwide use the SDGs as a framework to drive positive change and measure impact. This analysis has mapped the R2 impacts to the SDGs most directly impacted by the certification. This includes:

SDG 3 – Good Health & Well-being

R2 treats lead, mercury, batteries, CRT glass and other high-risk "Focus Materials" as special hazards, demanding dedicated handling plans, downstream verification and pollution-liability insurance. Controlling these toxins lowers community and worker exposure to harmful chemicals, contributing to SDG 3 target 3.9 on health impacts from pollution.



SDG 8 – Decent Work & Economic Growth

R2 bans child and forced labour, requires a non-discrimination policy and ties the whole system to a certified Environmental, Health & Safety management framework. These safeguards raise labour standards and worker safety across the electronics-reuse sector, advancing SDG 8 targets on fair employment and safe workplaces.

SDG 9 – Industry, Innovation & Infrastructure

Facilities must maintain digital records of every inbound, in-process and outbound stream and certify testing/repair operations under ISO-aligned quality systems, upgrading both technology and management. Those requirements directly support SDG 9's call to retrofit industries for resource-efficient, sustainable production.

8.4 Communicate the Relevant Sustainable Development Goals

SDG 12 – Responsible Consumption & Production

R2 builds a circular-economy “Hierarchy of Responsible Management Strategies” that makes reuse the first option and material recovery the fallback, directly addressing the waste-prevention targets in SDG 12. It also obliges facilities to track every shipment through the downstream chain, ensuring that electronics are actually reused or recycled rather than displaced.

SDG 13 – Climate Action

The R2 network helps deliver substantial greenhouse gas emission cuts thanks to avoided virgin production of new electronics. Coupled with certified recycling that prevents open burning and dumping, the standard gives companies a concrete tool for integrating climate-mitigation into their value chains.

Recommendations

A. Strengthen data collection and monitoring

B. Improve evaluation and evidence generation

C. Build facility capacity and encourage participation

9.1 Strengthen Data Collection and Monitoring

Continue Tracking Key Metrics and Expand Use of Surveys:
SERI and R2 Certified facilities should continue to monitor essential operational metrics such as the volume and type of used electronics processed, the number of devices reused or responsibly recycled, and reported workplace health and safety incidents. Incorporating periodic surveys targeting both facility managers and employees can help capture additional qualitative and quantitative insights, including changes in working conditions, exposure levels, and the adoption of best practices. This data will support long term impact evaluation and continuous improvement.

Standardize Data Reporting Across Facilities:
To ensure consistency and reduce reporting burdens, SERI could develop standardized templates or dashboards for R2 Certified facilities. These tools should include clear definitions, reporting indicators, and timelines across environmental, health, and reuse outcomes. Standardization would enhance data quality, allow benchmarking across facilities, and support aggregation of global impact metrics.

Expand Facility Type Disaggregation:
Facilities should be encouraged to report data disaggregated by facility type such as recycler or refurbisher. This level of detail would enable SERI to identify region specific challenges, recognize successful practices, and better support facilities operating in underserved or lower income areas.

9.2. Improve Evaluation and Evidence Generation

Address Data Gaps Through Strategic Partnerships:
To deepen the understanding of R2 Certification benefits, SERI should collaborate with academic, public health, and environmental organizations to investigate outcomes related to workforce demographics, occupational health, environmental performance, and the economic and social impacts of device reuse.

Integrate Impact Metrics into the Certification Process:
SERI could embed selected impact indicators into the R2 audit process to reinforce performance tracking. Metrics such as injury rates, environmental compliance, and reuse volumes/percentages would incentivize facilities to collect relevant data and highlight the outcomes of certification as part of ongoing compliance.

9.3. Build Facility Capacity and Encourage Participation

Support Capacity Building for Data Collection:
Recognizing that not all facilities have the resources to collect impact data effectively, SERI could offer guidance, training sessions, or technical assistance to support data collection on environmental indicators, occupational health, and device reuse. Tailored support would be especially beneficial for smaller or newly certified facilities.

Promote Transparency Through Public Reporting:
SERI should consider publishing anonymized, aggregate impact data in annual reports or public dashboards. This would demonstrate the value of R2 Certification to external stakeholders, increase public trust, and help position SERI as a leader in responsible electronics reuse and recycling.

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