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HANDBOOK

WEEEWaste Circular Practices Evaluation Tool (WCPET)

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1. EXECUTIVE SUMMARY

This handbook provides a comprehensive guide to using the WEEEWaste Circular Practices Evaluation Tool (WCPET). It includes detailed information on the tool's definition, theoretical framework, procedural steps, practical examples, and future development actions.

In the introduction of this handbook, you can find on the tool and its aim. In more detail this introduction, clarifies that the WEEEWaste Circular Practices Evaluation Tool (WCPET) is designed to evaluate and promote best practices in the circular economy. By using the R-Ladder framework and the WEEEWaste process design, WCPET helps partners assess current practices, learn from successful examples, and identify improvement areas. Key applications include selecting and screening best practices, identifying upstream opportunities, establishing a uniform methodology for measuring circularity in e-waste recycling, and comparing practices to enhance policy development.

Moving to the second chapter, you can find detailed information on the R-Ladder Framework and the development of that to the WCPET. Starting from the R-ladder, you can get guided through the transition from linear to circular production and consumption through the r-ladder strategies: Refuse (R0), Rethink (R1), Reduce (R2), Reuse (R3), Repair (R4), Refurbish (R5), Remanufacture (R6), Repurpose (R7), Recycle (R8) and Recover (R9).

Chapter three and four of the handbook analyzes WCPET's evaluation of circular economy practices through upstream resources and conditions, throughput activities for efficient transformation of inputs into outputs, and downstream results and impacts guiding strategy refinement. It also includes examples for each R-Ladder level, illustrating practice types and providing data for process design steps.

Chapter 5 outlines the steps to evaluate best practices using WCPET, including selecting a successful initiative, determining its rank on the R-Ladder, outlining the process, and assessing circularity to identify improvements. It also emphasizes sharing evaluations and feedback to refine the tool for better applicability.

Chapter 6 examines the Continued Development of WCPET: Continuous enhancement through user feedback and theoretical advancements will refine WCPET. The scoring methodology, incorporating rubrics and a Likert-style model, aims to distinguish optimal practices. The primary objective is to

strengthen WEEEWaste policy, transforming WCPET into a reliable tool for assessing and enhancing circular practices in e-waste recycling.

2. INTRODUCTION

The WCPET is a tool to evaluate 'best practices' in the circular economy domain on the basis of two criteria: (1) the R-Ladder by Potting and (2) the WEEEWaste process design. For each of the R-strategies, the process can be evaluated. The R-ladder framework is designed to measure and guide progress towards a circular economy by hierarchically organizing strategies to enhance circularity and sustainability. Using this tool, partners will have the opportunity to evaluate their best practices, visit examples, and observe other best practices to understand at which step of the ladder they currently stand, but also to get inspired on how they can improve.

This handbook outlines valuable insights on the practical applications of the tool, such as:

- **Selection of Best Practices:** The tool helps identify best practices for each of the R-ladder strategies.
- **Screening of Best Practices:** It provides insights into key areas of best practices in a specific region.
- **Insight into Upstream Opportunities:** It shows how to progress from a lower strategy (e.g., repair) to a higher level (e.g., reuse).
- **Sets a Uniform Methodology for Circularity Measurement in E-Waste Recycling:** It aims to develop a consistent approach for measuring circularity.
- **Comparing Best Practices:** It facilitates the comparison of best practices to enhance policy development.

3. THE R-LADDER

Introduction

The transition of CE and the R-ladder

The concept of the circular economy (CE) represents a departure from the linear "take-make-dispose" model, focusing on waste reduction and maximizing resource utilization as defined by Bakajic and Parvi (2018). CE aims to foster sustainable development by balancing environmental quality, economic prosperity, and social equity.

Transitioning to a circular economy involves shifting from linear production and consumption patterns to circular ones, emphasizing efficient resource use, waste reduction, and material reuse. Challenges include potential trade-offs where increasing circularity in one area may reduce it in another, and strategies such as chemical recycling may demand substantial natural resources and energy (Potting et al., 2018).

CE strategies like reducing, reusing, and recycling are pivotal in minimizing waste and extracting value from it. Waste loops are categorized into biological (returnable to nature) and technical (usable in industries) nutrients. Key strategies, known as R-imperatives, include reduce, reuse, recycle, redesign, remanufacture, and recover.

Monitoring CE progress involves tracking indicators such as energy consumption, resource utilization, and economic benefits to inform policy decisions and gauge effectiveness. In 2018, Potting et all. introduced the "circularity ladder" or R-ladder, a framework guiding businesses and governments toward increasingly circular practices. It outlines steps from less to more circular approaches, encompassing product redesign, material reuse, recycling, and energy recovery from waste. The R-ladder serves as a tool to assess and steer transitions to sustainable practices, emphasizing reducing and reusing to enhance sustainability over recycling (CBS, 2020; Potting et al., 2018).

In more detail, the R-ladder strategies are as follows:

"Refuse" (R0), wherein the deliberate abstention from acquiring products or raw materials is advocated. By eschewing purchases, substantial material savings are realized, thereby obviating the necessity for new raw material extraction.

"Rethink" (R1), emphasizing the intensified utilization of products through sharing or multifunctionality. Analogous to "Refuse," innovation, knowledge dissemination, and heightened awareness are pivotal in effectuating this strategy. By reassessing production chains and product applications, innovative solutions conducive to heightened product utilization are unveiled.

"Reduce" (R2) advocates for the judicious utilization of materials, thereby curbing the extraction of raw materials from the earth. This fosters more resource-efficient manufacturing processes or enhances product efficiency.

"Reuse" (R3), advocating for the repurposing of products to prolong their lifespan.

"Repair" (R4), which entails rectifying defective products to facilitate continued usage.

"Refurbish and re-manufacture" (R5 & R6) involves the rejuvenation of end-of-life products or materials to engender novel offerings of equivalent or enhanced functionality. "Re-purpose" (R6) advocates for repackaging products or materials for disparate functionalities, thereby imbuing them with augmented value.

“Re-purpose” (R7) involves the use of discarded products or their parts in a new product with a different function.

"Recycle" (R8) entails the reprocessing of materials into raw materials of commensurate or diminished quality, albeit at the cost of substantial energy expenditure and potential material quality degradation.

"Recover" (R9) revolves around harnessing energy from materials, thereby mitigating the necessity for outright incineration. This strategy, while less optimal, still confers utility through energy reclamation.

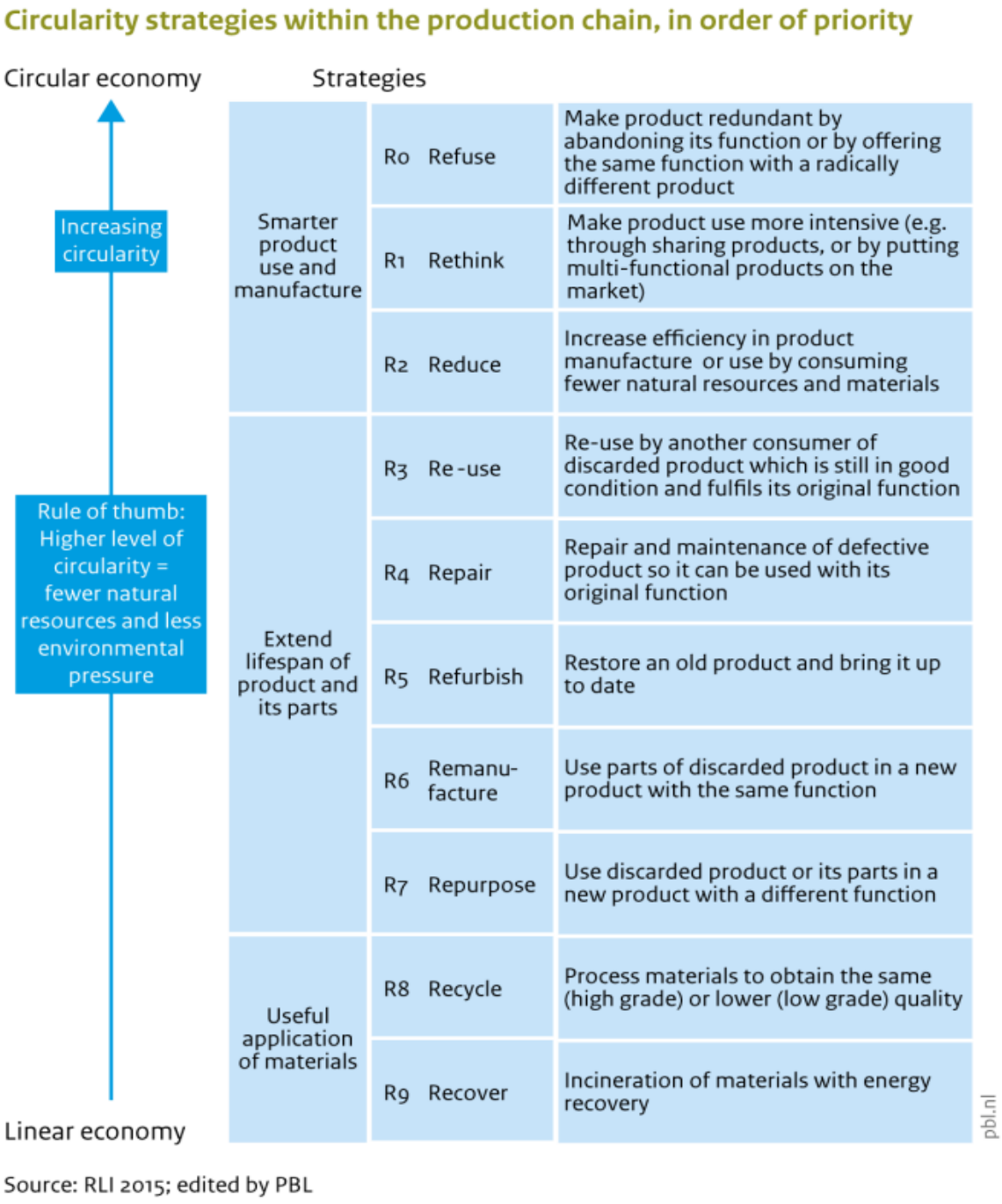

FIGURE 1: POTTING ET AL., (2018). ROLE OF INNOVATION IN CIRCULAR STRATEGIES FOR PRODUCTION CHAINS

4. Analysis of the WEEEWaste Circular Practices Evaluation Tool (WCPET)

As mentioned previously, the R-ladder is designed with several objectives in mind. It aims to facilitate the identification of optimal practices for each R-ladder strategy, provide insights into effective practices within specific regions, explore opportunities for progressing from lower strategies (such as repair) to higher ones (like re-use), develop a standardized methodology for measuring circularity in e-waste recycling, and enable benchmarking of best practices to improve policy development. To achieve these goals, the tool comprehensively examines the inputs, throughput, and outputs associated with best practices.

In the context of the WCPET framework, the terms input, throughput, and output are utilized to systematically analyze circular economy practices, particularly within the domain of Waste Electrical and Electronic Equipment (WEEE).

Upstream: In this framework, upstream refer to the foundational resources and initial conditions required to initiate circular economy processes. These include tangible elements such as new technologies or equipment, policy frameworks and financial investments, and considerations like the ambitions. Inputs are essential for setting up and sustaining circular practices, encompassing both physical resources and strategic investments necessary for implementation.

Throughput (Waste Management System): Throughput within the WCPET framework signifies the activities and processes that transform inputs into outputs. Examples include the development and deployment of new technologies, operational systems like sharing platforms and logistics for car sharing initiatives, and specific processes such as collection, sorting, and refurbishing at recycling hubs (e.g., Renew Hub in Greater Manchester). Throughput focuses on the operational phase where inputs are actively processed and transformed, ensuring efficient utilization of resources and effective achievement of desired outcomes.

D**ownstream**: downstream represent the measurable results and impacts derived from the throughput processes. These include environmental and social impacts such as reduced air pollution and changes in user behavior (e.g., decreased personal car use), as well as economic impacts like job creation and enhanced circularity. Outputs serve as critical indicators of the effectiveness of circular practices, providing insights into achieved benefits and areas for improvement. They guide ongoing refinement and optimization of circular economy strategies to enhance sustainability and maximize positive outcomes.

In summary, the WCPET framework employs input, throughput, and output as analytical lenses to assess and optimize circular economy practices related to WEEE. Inputs lay the groundwork, throughput operationalizes processes, and outputs measure and validate the outcomes, collectively fostering sustainable and efficient circular economy initiatives.

5. EXAMPLES

In order to exemplify the use of the tool we provide best practices per R-ladder step. These are just to showcase what kind of best practices 'rank' on which level of the tool, and what information can be given as input for the three process design steps.

Most of the examples cited are derived from successful practices featured on the Interreg Europe website or validated as such based on predefined criteria established by Interreg Europe. These examples span various European countries and offer valuable insights into diverse practices. The examples utilized include educational campaigns, the implementation of repair applications, establishment of incineration facilities, initiatives promoting a radical shift in public transportation vehicles, changes in mobility behavior, efforts towards product redesign, among others. A detailed table of these examples can be found in **Appendix 1**.

6. APPLYING THE TOOL TO YOUR BEST PRACTICE

The following steps can be taken while using the WCPET in order to evaluate your best practices.

Step 1. Best practice

The first step of using the evaluative tool is to select a best practice you want to evaluate. Interreg Europe has defined certain criteria to which we must adhere. These are as follows:

- An initiative related to regional development policy which has proved to be successful in a region and which is of potential interest to other regions.
- An initiative that has already provided tangible and measurable results in achieving a specific objective
- Since Interreg Europe is dedicated to improving regional development policies, a good practice is usually related to public intervention. In principle, a private initiative is not considered as a good practice', unless if there is evidence that it has already inspired public policies.

Step 2. Define the vertical line

The second step of the tool is to define where on the R-ladder your best practice would ‘rank’. As explained previously (see chapter 3. The R-Ladder). Important to note, is that you rate the circularity of what the best practice does with the waste. E.g. what happens with the waste after you collect it? Do you recycle it, or refurbish, etc? For further clarification we created a fully filled out tool with best practice examples on all levels of the ladder. Please see Appendix.

Step 3. Define the horizontal line

The third step is to define the horizontal line: the process. This consists of three categories: upstream, own process, and downstream.

3a. upstream (ambitions, aspirations, etc.)

The upstream are foundational resources and initial conditions required to initiate circular economy processes. E.g. new technologies or equipment, policy frameworks and financial investments, and considerations like the ambitions.

3b. own process

The own process are activities and processes that transform upstream into downstream. E.g. sharing platforms and logistics for car sharing initiatives, and specific processes such as collection, sorting, and refurbishing at recycling hubs.

3c. downstream (impact etc)

Downstream are the measurable results and impacts derived from the throughput processes, serving as critical indicators of the effectiveness of the circular practice. This includes environmental, economic and social impacts. This is all information related to the impact of the best practice. Data you can enter here are e.g.:

- Quality of repaired products
- Quantity of repaired products
- Productivity: output input
- Circularity: output total waste and output virgin material
- Ecological Impact (GRI)
- Financial impact
- Social impact (GRI)

Step 4. Evaluation

Based on the process of filling in the tool (as is), you will gather different insights. Firstly, where does your best practice 'rank' in circularity, and why? Is there anything that can be done (short to long term) to get a higher ranking in the R ladder? Moreover, what information might be missing in the horizontal line process? Can you still gather more information? What highlights are important to underscore?

For the next version of the tool, we will pay attention to the transferability. Meaning, how can we make the information best presented, so we can share insights with each other? Over time we will have our own database of best practices and can learn more from each other.

Step 5. Share best practice evaluation & feedback

During the partner meetings (online and offline) we will share with each other the best practices. Through the process of using the evaluation tool everyone will gather more critical insights on their own (and each other's) best practices and can thus share these during the meetings as well. This way we learn more from

each other, in order to improve policy. For now, we would also very much appreciate some user feedback, how did you experience using the tool so far? What can we do to improve it?

7. FURTHER STEPS FOR DEVELOPMENT

We already tried to capture some relevant attributes for the process design components. But these need to be put to the test, and more research needs to be done to see if the list of attributes needs to be extended. Furthermore, to be able to differentiate between 'best practices' a scoring methodology could be designed. Therefore, we need a set of rubrics for each of the design process (upstream, own process, downstream) attributes. Subsequently a Likert-like scoring model could be developed.

As previously discussed, we will continue to develop the tool based on user feedback and further theoretical development. We therefore also request your input after every iterative round of using the tool. Once we have finished the tool, it can then be continuously used for the ultimate goal of this project; to improve WEEEwaste policy.

8. APPENDIX

Table of examples

			Explanation of the step	Good Practice	Process design		
					upstream	Own Process	Downstream
R-ladder	Smart product use and manufac	**R0 Refuse**	Make products reductant by abandoning their function or by offering the same faction with a radically different product	**Organization:** TURDA MUNICIPALITY ROMANIA NORD-VEST **B.P: REPLACING THE ENTIRE PUBLIC TRANSPORT FLEET IN TURDA WITH ELECTRIC BUSES.** MORE INFO CAN BE FOUND HERE.	**AMBITIONS:** • Phase out old diesel buses • Introduce modern, eco-friendly buses • Promote public transport usage	**Prosses design:** • Development or acquisition of new, modern, eclectic, eco-friendly buses. • Financial and special capacity. (20 electric buses for 10.739.103 EUR). • SUMP measures for public transport. • Public-Private partnerships.	**Environmental impact:** • Replace old diesel buses with new electric buses to reduce air pollution. • Improve public transport with modern, eco-friendly buses. • Use ROP and SUMPs to promote low carbon public transport. • Turda pioneers' emission-free electric public transport in Romania.

	t u r e	R1 Re-think	Make products use more intensive (e.g. Through sharing products or putting multi-functional products in the market)	Case study Car sharing in Wageningen (Policy plan). Netherlands	Ambitions: objective of full climate neutrality in relation to mobility by 2050	Prosses design: • car sharing is relatively inexpensive for the governments. • The market develops the products and people share cars between them. • Requires the necessary alignment with policy development.	Environmental impact: • With a total of 150 shared cars, the municipality of Wageningen • is in 5th place in terms of the number of shared cars per 100,000 inhabitants. • the distances driven per driver were decreasing among shared car users. • there was a decrease in overall car use among car-sharers. • In the longer term, car-sharers were more likely to use a bicycle and, train and urban transport. Social impact: • changing the mobility culture
		R2 Reduce	Increase efficiency in product manufacture by consuming fewer material	Organization: **Fairphone**	• **Opposing the disposable culture.**	**Possess design:** • Product design • Administrative costs	**Impact:** offer spare parts on our website,

			resources and material.	 **Netherlands** **BP:** **phones with modular design** develop mobile phones with less impact on the environment	• **Promoting phone reuse and repair.** • **Researching electronics recycling.** • **Worldwide electronic waste reduction:** • **Enhancing customization** • **Simplifying upgrades.** • **Streamlining repairs.** • **Developing eco-friendly phones**	• Logistics • Investments • Research • Up-to-date technological knowledge.	as an industry-first. lower environmental footprint, with a more robust and longer-lasting modular design and another camera modules upgrade. New Fairphone 4: comes with a 5-years extended manufacturer warranty to encourage our users to opt for repair instead of replacement. It supports 5G to ensure that it will not become obsolete due to technological developments on the network level.
	Extendli	R3 Re-use	Re-use by another consumer of discarded products that are still in good condition and fulfil their	**Organization:** SUEZ RECYCLING AND RECOVERY UK	**Ambitions:** Increase the amount of electronic equipment collected and repaired while at the	**Process design:** **Collection:** • Drop off donation containers **(*unable to collect items)**	**Outputs and impact:** Productivity: Output #/Input • 217 tonnes of pre-loved

	f e s p a n o f p r o d u c t a n d i t s p a r t s		original function	 United Kingdom B.P: **The Renew Hub – Reuse on an industrial scale** Renew is an ambitious and unique project which aims to create value from waste to benefit Greater Manchester. It's a joint initiative between R4GM & SUEZ UK. We take items donated at recycling centres across Greater Manchester, then we repair and renew them at our Renew Hub, ready to be resold to a new home. For more information here.	same time increasing the number of devices that users re-use by: • waste prevention • significantly reduce the amount of waste going to landfill. • retain the value of re-used products and the creation of jobs in the local economy	• Capacity, logistics, collection vehicles, collection containers, • Renew hub: The UK's largest re-use facility, where we upcycle, fix, and refurbish items donated at Recycling Centres. **Sorting/separation:** ✓ Furniture ✓ Electricals ✓ Toys ✓ Bric-a-brac ✓ Collectables/vintage ✓ Bikes and sports equipment ✓ Gardening and DIY ✓ White goods **Resell:** • 3 renew physical stores • Online stores • eBay store	items were repaired and re-sold in 3 Renew shops Circularity & Ecological Impact (GRI) Money are being donated to Recycle for Greater Manchester Community Fund. *£220k/year to the above project and projects aimed at reducing waste and increasing reuse; 17 FTE jobs & apprenticeships Economic impact: • Create new business models • Create new job opportunities. Social Impact (GRI) Money are being donated to Greater Manchester Mayor's Charity *£100k/year

							• Establish educational centers for students and citizens • Creating awareness around the proper recycling *Initial evidence of refurbishing and remanufacturing initiatives
		R 4 Repair	Repair and maintenance of defective products so they can be used with their initial function	**Organization:** Office of the Regional Government of Styria BVG AUSTRIA STEIERMARK **BP:** **ONLINE GUIDE FOR REPAIR SHOPS** THE ONLINE GUIDE "REPARATURFUEHRER.AT/STEIERMARK" WAS CREATED TO MAKE IT EASIER FOR THE PUBLIC	**Ambitions:** 1. Easily accessible and up-to-date information for the public on where to find repair services. 2. Increase the number of people that chose to repair their products and the number of products that are being repaired.	**Process design:** • Application design • Technical updates/maintenance. • Data maintenance and data entries. • Working force. • Real-time access to information.	**Quantity of repaired products:** total number of repair service offers across all categories entered in the Styrian online repair-guide is ca. 1,900. In 5-months funding period of the application in 2019, the number of repair shops for electric and electronic household appliances listed in the online guide has doubled to about 500, with ca **Circularity:**

				TO FIND QUALIFIED REPAIR WORKSHOPS IN THEIR AREA. FOR MORE INFO HERE			Increased number of products that got repaired and reduction of products that got recycled **Social Impact (GRI):** Provide sustainable repair solutions in affordable prices
		R5 Refurbish	Restore an old product and bring it up to date	**Organization:** mt unirep **Germany** **BP:** Working towards a circular economy Refurbishment https://www.mt-unirepair.com/	**Ambitions:** • refurbishment and repair of electronic equipment and machinery. Aim to extend the lifespan of products, reduce waste, and promote sustainability.	Refurbishment Services: Reverse Logistics: Sustainability Focus: Minimizing waste and reducing the demand for new raw materials by extending product life cycles and implementing eco-friendly solutions.	**Quality impact:** • Ensuring that refurbished equipment not only functions optimally but also look like new through re-painting, cleaning, and cosmetic enhancements. Cost-Effective Solutions: Offering refurbished products as a cost-effective alternative to buying new.
		R6 Remanufacture	Use parts of discarded product in a new product	**Location**: Netherlands	Extend the lifespan of office equipment.	• Process Design:	• Cost-Effective Solutions: Offering refurbished

			with the same function	**BP:** Remanufacturing of office printers, toners and photocopiers	Reduce electronic waste by reusing functional components. Promote sustainability and circular economy practices.	• Collection of end-of-life office printers and photocopiers from businesses and recycling centres. • Initial assessment to determine which parts can be reused or refurbished. • Throughput (Waste Management System): • Careful disassembly of collected equipment to separate functional parts. • Cleaning and refurbishing parts to ensure they meet quality standards. • Testing: Rigorous testing of refurbished parts to ensure functionality. • Using refurbished and tested components to assemble new office	products as a cost-effective alternative to new ones. • Circularity: Significant reduction in waste by extending product life cycles. • Social Impact: Creating awareness around the proper recycling and sustainable use of office equipment.

						printers and photocopiers. • Quality Control: Implementing stringent quality control checks to ensure re-manufactured devices meet or exceed original manufacturer specifications.	
		R7 Re-pur-pose	Use discarded product or its parts in a new product with a different function	**Organization:** **Weee NL. & Re-furn** **& Vattenfall**  **Netherlands** **BP:** Refurbished charging stations Purchases refur-bished stations and parts for continued use. For more info here	**Ambition:** • Promote the reuse of electronic components. • Extend the lifespan of charg-ing stations. • Reduce electronic waste by refur-bishing existing equipment	**Process Design:** • Collection: Gathering end-of-life charging stations and parts from vari-ous sources. • Initial Assess-ment: Evaluat-ing collected items to identify reusable com-ponents. • Throughput (Waste Man-agement Sys-tem): • Disassembly: Systematic dis-assembly of charging sta-tions to extract functional parts. • Refurbishing: Refurbishing	**Environmental Impact:** • Waste Re-duction: Sig-nificant de-crease in electronic waste by re-using com-ponents. • Resource Conserva-tion: Lower demand for new raw ma-terials and energy. • Emission Reduction: Reduced greenhouse gas emis-sions com-pared to manufactur-ing new equipment.

						extracted components to ensure they meet quality and safety standards. • Testing: Comprehensive testing of refurbished parts and assembled charging stations to guarantee performance. • Reassembly: Using refurbished parts to assemble charging stations that are as good as new. • Quality Control: Ensuring all remanufactured charging stations meet or exceed original specifications through rigorous quality control.	**Economic Impact:** • Cost Savings: Offering cost-effective alternatives to new charging stations. • Business Opportunities: Development of new business models cantered around refurbishment. • Job Creation: Creating employment opportunities in the refurbishment sector. **Social Impact:** • Consumer Awareness: Raising awareness about the benefits of refurbished products.

							• Sustainable Habits: Encouraging sustainable consumption habits. • Local Economies: Contributing to local economies through job creation and business development.
	Useful application of materia	R8 Recycle	Prosses materials to obtain the same (hight grade) or lower (low grade) quality	**Organization:** Centro di Coordinamento RAEE ITALY LOMBARDIA **BP: WEEE@SCHOOL** **THE AIM OF THE PROJECT IS TO INFORM AND COMMUNICATE TO THE CHILDREN WHAT WEEE ARE, THE CORRECT WAY TO COLLECT THEM AND THE IMPORTANCE OF**	**AMBITION:** • Create awareness, sensitize and educate children about the recycling of electric and electronic equipment	**Process design:** • Financial recourse nodded (500.000 euro for each edition) • Trained, expert personell. • Administrative arrangements (classrooms, personell, etc)	**Social impact:** • The project's approach effectively keeps children motivated and interested in the subject. • The practice offers valuable insights for other regions and cities. • improve knowledge and raise awareness about the collection, treatment, and recycling of electronics at

	ls			**THE RECY-CLING.**			the end of their life.
		R9 Recover	Incineration of material with energy recovery	**Organization:** Fortum Waste Solutions **BP:** Waste-to-Energy More information in the following link https://www.fortum.com/services/recycling-waste/waste-management-services/waste-energy	**Ambition:** Turning waste to energy	**Process design:** • Financial resources, • Logistics • Human resources •	**Electricity generation:** Fortum's facilities produce electricity from the combustion of waste, contributing to the local energy grid. **Heat recovery:** Besides electricity, the heat generated during incineration is used for district heating purposes, enhancing energy efficiency. **Residue management:** Ash and non-combustible residues are carefully managed and processed to minimize environmental impact and maximize resource recovery.