Extended Abstract
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Beyond Ownership: The Environmental Impact of Rent, Repair and Refurbishment of ICT devices

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Introduction

Electronic devices, especially information and communication technology (ICT), are integral to our daily lives. While these devices offer benefits, their production and disposal significantly impact the environment. E-waste is the fastest-growing waste stream (Balde et al. 2024), and many electronic products are replaced before their technical lifespan ends (Magnier & Mugge 2022). Extending the service life of these devices can reduce their environmental impact. Circular business models aim to prolong product life, often through multiple users, and enhance resource efficiency via practices like leasing, resale, and refurbishment.

In our study, we examine the life cycle impacts of circular business models on service life and sustainability, focusing on smartphones, laptops, game consoles, and cameras, utilizing real activity data collected from associated partners in project *Undress Circularity* and conduct user surveys regarding the usage and purchase activities of these products in Germany.

Circular Business Models

A circular business model (CBM) incorporates circular economy principles (such as re-use, recycling) into business operations, contrasting with traditional linear models that follow a 'take, make, dispose' approach. CBMs try to minimize waste and maximize resource efficiency by keeping products in use longer. Our study focuses on existing business models that provide access to ICT devices beyond conventional new sales, rather than on hardware design.

Koide et al. (2022) found that circular strategies like repair and refurbishment offer moderate to high environmental benefits compared to linear models, albeit with potential rebound effects reducing actual benefits. Similarly, Poppe et al. (2024) indicate that savings from circular economy strategies vary widely, with ICT products showing savings of 24-91% compared to new purchases. This variation results from differences in empirical data quality and underlying methodological choices (Poppe et al. 2024).

The potential of reducing environmental impacts through circular business models lays in the reduced number of products needed to fulfil the same useful service life. This can arise from activities such as:

- Reuse and Refurbishment: Extending the life of a product by repairing or refurbishing it avoids the emissions associated with manufacturing a new product.
- Product-as-a-Service Models: Offering products as services (e.g., leasing or renting) can optimize the use of resources and minimize waste, leading to emission reductions.

Thereby there are significant differences in circularity potential between continuously used products (smartphones and laptops) and discontinuously used products (game consoles and cameras).

For continuously used products, extending service life is a primary focus. Maintaining and refurbishing devices can lead to multiple lifetimes of use—encompassing the first, second, and potential third lifetimes—which is vital for reducing environmental impact. In contrast, discontinuously used products present a different challenge; their circular potential lies in reducing the overall number of products required through improved utilization strategies.

Scenario development for impact measurement

Our methodology aligns with life cycle assessment (LCA) principles, focusing on quantifying emissions across different scenarios. The analysis compares a pure linear scenario (purchase, single-user use, disposal) with a baseline scenario reflecting existing reuse in the market. This is contrasted with professional reuse and rental scenarios (see exemplarily Figure 1).

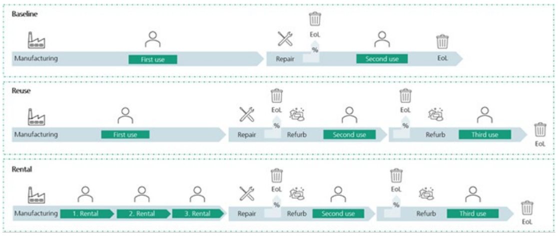

Figure 1: Comparison of different impact models [graphic by IZM]

Given that rental or resale models may appeal to specific user demographics, it's crucial to control for these factors in assessments of avoided emissions (WBCSD 2023). However, a lack of data leads to mixed scenarios that compare user-specific solutions to market averages, which may not accurately reflect avoided emissions.

Our approach thereby has the goal to show the potentials and levers of current circular business models based on real activity data – with all the connected interlinkages – rather than allowing to claim avoided emissions by a single actor.

Current product use in Germany

To establish a realistic scenario for the current product use in Germany compared to the potential benefits a CBM could offer, a user survey was conducted with the project Undress Circularity to assess the current use and flow of devices in Germany and the already existing establishment of CBM in Germany. For private and business users of ICT devices where asked about the time they use their devices, how they buy and dispose them and which factors influence their behaviour. (For the more detailed results of the survey see Circularity e.v. 2024) Based on this user survey and additional literature, the flow of ICT equipment in Germany is analysed. The majority of devices are purchased as new (86%), while 14% of devices are second-hand. Among the devices entering the after-use phase, 27% are being replaced due to defects, whereas 73% are still functional but are no longer used for other reasons. More than 35% of all devices are intended for reuse after-use, leading to a positive net-flow of second-hand devices. 22 percentage points more devices are leaving the system intended for reuse than are entering it. This positive net flow across all product categories indicates that, within the considered market scope, more devices for reuse are leaving the system in after-use than being introduced as second-hand. This surplus highlights the potential for increased circularity across all product groups, but also shows that demand for second-hand devices in Germany is 17% to 28% lower than the after-use supply in this region.

Approximately 18% of all devices are sold, while around 5% are traded in. Notably, only 31% of devices are recycled, whereas 16.5% of devices are stored as backups, and 5.5% are set aside for alternative uses (see Figure 2).

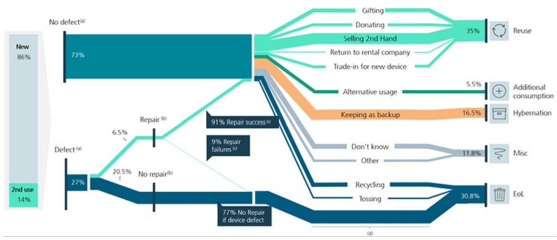

Figure 2: Approximated flow of ICT devices after use in Germany (2020-2024) [graphic by IZM]

Both smartphones and laptops exhibit comparable defect rates before the after-use phase, each around 40%. However, a significant difference emerges in the repair rates: while only 24% of defective smartphones are repaired, laptops show a much higher repair rate of 40%. This suggests that laptops have a longer second life potential through repairs, whereas smartphones are more likely to be discarded or replaced after defect.

Games consoles present a unique profile, with a relatively low defect rate of 19% before after-use. Interestingly, if a defect does occur, games consoles have a high repair rate, with 36% of defective devices being repaired. This combination of low defects and high repair potential positions games consoles as one of the more durable product categories in the analysis.

Conclusions

The research reveals that circular business models are often interlinked, with various stakeholders involved in the rental and resale markets. Notably, rental companies frequently do not directly provide the services associated with product usage (like repair, refurbishment, data deletion between rental periods), leading to complexities in evaluating their effectiveness. While renting tends to be less favorable when considering the actual rental service life, the data indicates that rental services often facilitate second-use opportunities more frequently than traditional sales.
Furthermore, rentals and professional resale services typically concentrate on a select range of high-end devices, which correspondingly exhibit higher rates of private reuse and resale. By analyzing the life cycle impacts of these CBMs, this study will provide valuable insights into optimizing product utilization and fostering sustainable consumption patterns in different electronic product categories.

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