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Circular economy & stigmatized industries: identifying barriers and opportunities at a systems-level for adult sex toys

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ABSTRACT

The adult sex toy industry, valued at $33.64 billion in 2020 and growing 26% during the COVID-19 pandemic, faces waste management challenges due to the use of electronics, plastics, and silicones, necessitating circular economy (CE) solutions. This study, grounded in CE and the multi-level perspective (MLP), uses industry stakeholder interviews and analysis of nine popular products to identify barriers and opportunities for CE strategies in this industry. New barriers include stigma, industry-specific challenges, product challenges, and consumer behavior, while eco-design emerges as a significant area for improvement. Identified opportunities involve government intervention, overcoming stigma, adopting eco-design principles, fostering value chain collaboration, learning from other industries, and developing effective recovery strategies. The study also discusses specific barriers at each MLP level, including battery and silicone recovery, retailer volume dilemmas, and navigating stigma for inclusion in policy. The sex toy industry exemplifies the complexities firms face in implementing CE strategies from a systems-level lens, contributing new empirical data to barrier discussions in SMEs, stigmatized industries, and industries new to CE strategies, supporting a sustainable transition.

KEYWORDS

Circular economy, multi-level perspective, adult sex toy industry, barriers, opportunities

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1.0 INTRODUCTION

As more reports come out providing continued evidence of climate change impacts each year (see the latest state of the planetary boundaries by Richardson et al., 2023), there is increased urgency for action to address climate change. To this end, more organizations are claiming to take steps supporting sustainability, as well as countries and individual citizens (McGrath, 2024; Deloitte, 2023), thereby collectively making progress on this global issue. Part of this urgency and collective action includes an awareness that all industries must transition to operate sustainably with respect to the Sustainable Development Goals (SDGs) and planetary boundaries, which notably do not exclude any industry. While many topics have gotten attention and sustainability research, it has been overwhelmingly focused on manufacturing industry cases, like scrap sheet metal repurposing (Kirchherr & van Santen, 2019), creating gaps and limiting the knowledge to support other industries.

As Hodgson, Piscicelli, Frenken, & Williams (2024) state, the service sector, with industries like hospitality, hairdressing, and healthcare, is underrepresented in research although it is vital to the economy. In this sector, services are often provided on a small-scale, vary widely in resource usage, and involve close interaction with customers. More similarly to the service sector, the adult sex toy industry has unique characteristics and focuses on consumer products that are not represented in current research, challenging the adoption of sustainability concepts like circular economy strategies, often derived from manufacturing-specific contexts (Hodgson et al., 2024). The industry experienced a 26% increase in market size during the COVID-19 pandemic and was valued at $33.64 billion globally in 2020 (Qalati, Limón, & Bhayo, 2022). This market growth poses an increasing waste problem due to the linear consumption pattern of these products and lack of sustainable solutions for handling the waste, therefore overwhelmingly going to landfills. When considering the waste, it is key to understand what materials and components are used. The

most common components and materials used in sex toys are electrical and electronic equipment (EEE), plastics, and silicones (Hald, Pavan, & Øverup, 2024; Sipe et al., 2023). By focusing on the materials comprising these items, there is the potential to extend sustainable solutions to these products too.

1.1 Research Context

To better understand the setting of the research, it is beneficial to outline the context of the industry, in addition to the market size. The sex toy industry is a subsection of the sexual wellness industry (Hald, Pavan, & Øverup, 2024). Sex toys are defined as devices or items used to facilitate human pleasure, like vibrators, dildos, anal toys, and other related products (Hald et al., 2024). In 2021, global quality and safety standards for materials used when manufacturing these products were published (ISO 3533), but do not cover environmental impact concerns (International Organization for Standardization, 2021). Furthermore, despite Western societal liberalization, consumer sensitivity and taboos still influence consumer behavior (Piha, Hurmerinta, Sandberg, & Järvinen, 2018), and therefore the industry business strategy. In addition, these items are sometimes considered biohazards at recycling firms making the waste streams more complex (Hay, 2022). For example, one retailer who has operated a recycling program also cited sterilization concerns at return and disassembly as a specific variable to this industry (Hay, 2022). In addition to what is happening in practice, academic research on sex toys is scarce (Döring & Pöschl, 2018) and has not addressed sustainability.

As mentioned above, these items use EEE, plastics, and silicones. EEE is present in vibrators and other electric toys (Hald et al., 2024). Plastics are commonly used, particularly in vibrators (Sipe et al., 2023). Similarly, silicones find extensive application in toys like dildos and anal toys (Sipe et al., 2023). Recent publications on these materials, not specific to sex toys, shows the current research, innovation, and magnitude of production & waste.

Plastics have ongoing innovations and upcycling is an efficient way to reuse the material (Zhao et al., 2022). In 2022, 380 million tons of plastics were produced worldwide, with less than 20% typically recycled (Zhao et al., 2022) showing significant waste and opportunity. Likewise, silicone research emphasizes the importance of recycling and recovering these high-value polymers due to substantial global production volumes with over 8 million tons produced annually worldwide in 2020 (Vu, Boulègue-Mondière, Durand, Raynaud, & Monteil, 2023).

Studies on waste electrical and electronic equipment (WEEE) detail challenges such as circularity barriers and consumer behaviors. Meanwhile, 53.6 million tons of WEEE was generated worldwide in 2019 (Islam et al., 2021). More specifically in the WEEE category are lithium-ion batteries, and are present in sex toys toys today. Lithium-ion batteries are projected to grow to two million tons of waste annually by 2030, emphasizing the need for recycling solutions to avoid depletion of natural resources and environmental harms like water contamination (Krishna, Shaji, Mohanraj, & Ulaganathan, 2024). Similarly, the classification of 900 WEEE items adopted by the EU WEEE Directive (Forti, Baldé, Kuehr, 2018) goes to a level of detail about wristwatches, but does not include sex toys, indicating a lack of inclusion in large-scale definitions.

The linear economy prevalent in the sex toy market today, combined with project market growth, contributes to intensifying waste issues. As shown however, there are parallels between the materials used by the sex toy industry and that of other sectors, such as electronics, plastics, and silicones, all of which have existing solutions for circularity. Recognizing these parallels presents an opportunity to incorporate CE concepts into the sex toy industry and potentially mitigate negative effects on the environment caused by this industry.

Therefore, the research question is: *what are the barriers and opportunities for transitioning the adult sex toy industry to incorporate circular economy strategies?* This research aims to identify the barriers and opportunities for the sex toy industry to apply circular economy strategies. The objectives are: understand current awareness and state of CE implementation by participants; identify the barriers perceived by manufacturers, retailers, and waste managers to implement circular strategies; identify the shortcomings mainly regarding product characteristics and information disclosure through product analysis; present opportunities for this industry to implement circular economy strategies. Barriers are defined as challenges or difficulties hindering advancement of CE strategies, like expertise requirements or consumer demand for sustainable products. Opportunities are defined as solutions related to barriers, like communication or policy. The definitions for barriers and opportunities are adapted from Rizos et al., (2016).

2.0 THEORY

It is key to establish a conceptual lens for the research, starting with defining the circular economy (CE)**.** Since the late 1970s, concepts creating the roots of the circular economy originated as regenerative design and the performance economy (Ellen MacArthur Foundation, 2013). Many concepts that now support CE have gained momentum since, like biomimicry, industrial ecology, and cradle-to-cradle (Geissdoerfer, Savaget, Bocken, & Hultink, 2017). While the Ellen MacArthur Foundation published the widely assumed definition of the CE in 2013, the definition provided by Geissdoerfer et al. (2017) is the most helpful for this research. They describe it as a regenerative system where resource leakage is reduced or closed by addressing material and energy loops. This includes practices of maintenance, long-lasting design, and the frequently referred to R-strategies like reuse, repair, remanufacture, recycling and refurbishing (Geissdoerfer et al., 2017; Reike, Vermeulen, &

Witjes, 2018). The CE is a concept under the wide umbrella of sustainability methods, theories and concepts; some even state that a condition of sustainability is the CE (Geissdoerfer et al., 2017). In business, CE involves companies integrating circular strategies into their operations, whether they are new or an incumbent adapting their business model (Awana, Chavan, Sedera, Cheng, & Ganzin, 2024; Rizos et al., 2016)

The sample present in this research is predominantly small and medium enterprises (SMEs). Existing literature on SMEs integrating CE strategies highlights several barriers: lack of supply and demand network support, insufficient capital, lack of governmental support, administrative burden, limited technical know-how, insufficient information, and company environmental issues (Rizos et al., 2016). In addition to barriers for SMEs, some specific barriers are noted for circular start-ups that are similar to the findings here, as identified in a study on Australian firms. This includes lack of collaborations, sales challenges, consumer challenges, marketing and advertising difficulties, and sustainable packaging issues (Awana et al., 2024). Another noteworthy complex phenomenon that also occurs in sustainable entrepreneurship, and present in this study, is the green prison (Pacheco, Dean, & Payne, 2010). The green prison uses the prisoner's dilemma metaphor to understand the choices made by entrepreneurs, where they are "compelled to environmentally degrading behavior" because there is a tension between collective goals and individual benefits for sustainability (Pacheco, Dean, & Payne, 2010).

In addition to CE, the multi-level perspective (MLP), first introduced by Rip & Kemp (1998) and further developed by Geels & Schot (2007), is helpful to understand sustainable transitions. The MLP visualizes (Geels & Schot, 2007) the non-linear transition process of socio-technical systems with interactions between the landscape (macro), socio-technical regime (meso), and innovation niche (micro). Each level includes multiple elements, co-evolves across activities on the multiple levels and increases in stability with each

ascending level (Wang et al., 2022). This research also defines sustainable transition as a fundamental, multi-dimensional, and long-term transition of production and consumption across various dimensions of technology, organizations, institutions, economics, politics, materials, and culture (Markard, Raven, & Truffer, 2012).

The MLP has a widely used visual depiction accompanying it with phases of change on the X axis (experimentation, stabilization, diffusion / disruption, institutionalization / anchoring), then the three levels ascending on the Y axis (niche-innovations, socio-technical system, and socio-technical landscape). The perspective posits that new firms innovate and experiment on the fringe of the current system, momentum increases and the innovation stabilizes, then there is a break in the landscape creating an opportunity for the innovation to break through the current regime at some time, the innovation is adopted and influences the landscape moving forward (Wang et al., 2022). Combining the two concepts - CE and MLP - provides a theoretical lens to utilize when assessing the findings of the research at a socio-technical system level.

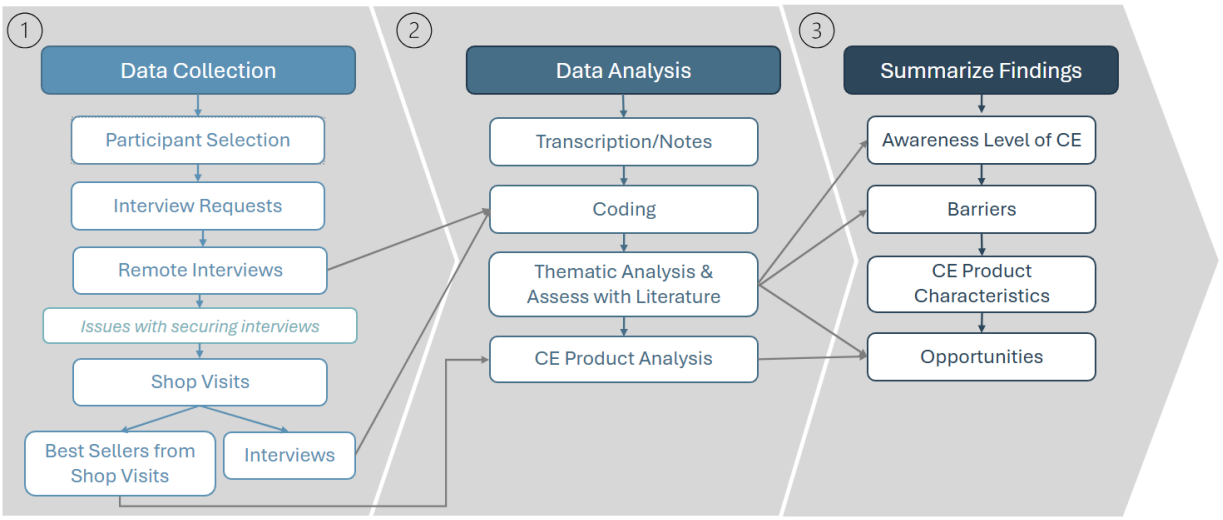
3.0 METHODS

3.1 Research Design

To address the research question, a qualitative research design utilizing semi-structured interviews (Adams, 2015) is the most suitable approach due to the lack of existing research on the intersection of CE and sex toy industry. This study employed approachable, open-ended questions focused on barriers and opportunities to understand the factors influencing the system (Chenail, 2011). The research involved stakeholders from the globally distributed sex toy industry, which is appropriate given the industry's global value chain and the companies' operations across multiple countries, providing diverse perspectives across the value chain. Figure 1 below illustrates the research process from data collection to

analysis and summarizing the findings, which aids in understanding the research methodology. The gray lines indicate the flow of various types of data from collection to findings to address the research question.

Figure 1: Summary of Methods



3.2 Data Collection

3.2.1 Participants selection

Participant selection employed a multifaceted approach, beginning with an exploration of gray literature (Park, Kim, & Choi, 2019; Maula & Stam, 2020) to identify retailers and manufacturers committed to sustainability, using search terms like "sex toy recycling" and "sex toys sustainability." Additionally, waste managers and innovators from Dutch organizations implementing circular economy (CE) principles were identified, given the Netherlands' strong commitment to CE initiatives and proximity. This was done using search terms such as "Dutch waste managers sustainability" and "Dutch circular economy companies."

Purposive sampling techniques (Bell, Bryman & Harley, 2019) were used to identify individuals in relevant companies and appropriate participants. The rationale for selecting

specific companies over others was based on factors like sustainability-related goals and relevance to the research objectives. Despite extensive outreach via email, LinkedIn, and phone calls between March and May 2024, a low response rate presented a significant challenge. Concerns about possible harassment from the general public, as stated by one participant, necessitated a cautious approach to recruitment creating a limitation on pathways to contact potential participants. To mitigate this, in-person shop visits were conducted in May 2024, prioritizing locations near the researcher due to time constraints, using search terms like "sex shops [town]" or "erotic shop [town]." Despite these efforts, no responses were received from industry innovators, leading to their exclusion from the research.

3.2.2 Interviews

This research methodology involved both online and in-person approaches, comprising seven confidential semi-structured interviews with anonymized transcriptions (Figure 2). The number of employees is presented as a range to maintain organizational anonymity. Online interviews, lasting 30 to 60 minutes, were recorded for transcription, coding, and analysis. In contrast, in-person shop visits, lasting 15 to 20 minutes, were not recorded due to customer privacy concerns. Instead, detailed notes were taken and transcribed immediately after each visit for subsequent coding and assessment.

Interview guides (Appendix A) were customized for waste managers and retailers/manufacturers. The interviews covered topics such as awareness of CE, expanded definitions of CE, utilization of CE strategies, and barriers at the company, industry, and society levels. A CE scale, adapted from Garza-Reyes et al. (2018), was used to standardize ratings of participants' company implementation of CE strategies (Appendix A). This scale was only shown to participants during the relevant interview question and was not used in in-person shop visits due to their lack of CE knowledge. Follow-up questions were

occasionally sent via email for clarification, with all but one company responding for inclusion in the findings.

Figure 2: Summary of Participant's Organizational Information

Label	Stakeholder Type	Role in Company	Country of Origin	Number of Employees	Top Service or Products Sold	Raw Materials of Products
WM	Waste Manager	Head of Communication & Marketing	Netherlands	400 - 600	Waste collection and treatment services	Glass, paper, textiles, metals, plastics
Manuf 1	Manufacturer	Co-Founder	United Kingdom	5 - 30	Sustainable sex toys	Aluminum, bioplastic, electronics, silicone, battery, water
Manuf 2	Manufacturer & Retailer	Head of Brand Design	Netherlands	400 - 600	Sex toys, vibrators	Silicone and plastics
Ret 1	Retailer	Senior Buyer	Canada	5 - 30	Sex toys, vibrators, lubricants, condoms, books, accessories	Silicone, metals, steel, plastic
Ret 2	Retailer	CEO & Co-Founder	United States	5 - 30	Vibrators, lubricants, accessories	Battery, plastic, silicone, electronics
Ret 3	Retailer	Sales Associate	Netherlands	1 - 5	Vibrators, anal toys, electric masturbators	Latex, rubber
Ret 4	Retailer	Owner	Netherlands	1 - 5	Vibrators, dildos, electric masturbators	Silicone

3.2.3 CE Product Analysis

In addition to conducting interviews, data collection included inquiries at shops \to identify their top three best-selling products. The objective of scrutinizing product packaging was to gather insights into the products' lifecycle, material composition, and potential for circularity, aligning with the goal of exploring improvement opportunities. Photographs of product packaging were taken during these visits for data collection. This method was applied in three shops, two of which were also interviewed.

To ensure a systematic evaluation, a checklist (Appendix E) based on Mora-Contreras, Torres-Guevara, Mejia-Villa, Ormazabal & Prieto-Sandoval (2022) was developed and reviewed with the supervisor for appropriateness and accuracy. This checklist structured the product analysis process, aiding in the collection of relevant data and insights from the packaging materials. A total of nine items were identified during the shop visits: three external vibrators, one insertable vibrator, two masturbators, two anal plugs, and one dildo. This analysis was not limited to sustainably advertised items; it was open to any sex toy sold in the store.

3.3 Data Analysis

3.3.1 Interviews

In this study, interviews were used to collect data, allowing for an in-depth exploration and analysis of the research question. Recordings and transcriptions of these interviews were coded using ATLAS.ti software, employing both first and second-order methods as outlined by Goodrick and Rogers (2015). The coding approach combined inductive reasoning for first-order codes and deductive reasoning for second-order codes (codes detailed in Appendix D). Second-order codes were derived from themes identified in existing literature on circular economy (CE) barriers, particularly Geissdoerfer, Santa-Maria, Kirchherr, & Pelzeter (2023).

Geissdoerfer et al. (2023) examined the implementation of circular strategies in businesses of various sizes across five European countries and 15 industries, encompassing both business-to-business and business-to-consumer products and services. This study similarly examines seven organizations, three stakeholder types, and spans four countries in North America and Europe focused on one industry. The multi-industry perspective of Geissdoerfer et al. (2023) is relevant, highlighting barriers beyond a single industry, such as those experienced by different stakeholders in the value chain. They identified financial,

legal, market, technical, organizational, and value chain barriers, which are also used in this study's coding. Rizos et al. (2016) found similar barriers for SMEs without adding new ones and thus were excluded from this analysis. Awana et al. (2024) focused on Australian circular economy start-ups who create value from waste (like industrial symbiosis) or develop scale-up solutions (like incubators), and are in the early stages of business development. Their findings are discussed but not included in the findings due to more differentiation in participant selection.

An organizational table and a CE scale were created during data analysis to enhance clarity. Specific to the CE scale and rating by participants, Ret 3 and Ret 4 were both rated by the researcher from the information shared in the previous questions as they had no prior understanding of CE. The most common and novel second-order codes and themes were then overlaid onto the MLP visual (Figure 6), providing a systems-level view. The placements of each code on the visual was based on where the researcher understood the code to occur in the system. The top three second-order codes and associated theme per barrier were selected to highlight (Figure 5); each barrier in each level is sorted from highest to lowest count of quotes. This analysis was supplemented by research on CE, sustainable transitions, and circular use of materials to support credibility (Bell, Bryman, & Harley, 2019).

3.3.2 CE Product Analysis

During visits to the three shops, nine products were identified and photographed for the CE product analysis. To ensure thorough documentation, photos of all sides of the packaging were taken, avoiding obstruction by price stickers or similar markings. Each photo was meticulously reviewed against the predetermined CE product analysis criteria (Appendix E) like key language and symbols that could fulfill the criteria. Additionally, digital copies of user manuals or instructions were obtained for each product, if available, to provide further

detail. This data was then compared to the themes identified in the interviews, ensuring all barriers and opportunities were identified.

3.4 Ethical Considerations

As with any research involving people, this study followed the ethical requirements and considerations in accordance with the University of Groningen policy. The interviews utilized an information sheet and informed consent. Data from the interviews and focus group were confidential and anonymized at transcription and not disclosed without consent. The data was stored securely according to University policies, in addition to having ethical approval from the Campus Fryslân Ethics Committee.

4.0 RESULTS

The following section is organized in four subsections: current organization CE state, barriers, opportunities, and a product analysis of circularity. Each section builds on the previous to construct a full image to understand the current state activity at the organizational (micro), industry (meso), and society (macro) perspectives from the interviews and product analysis data, aligning with the levels of the MLP.

4.1 CE in the Sampled Organizations

4.1.1 Current awareness of CE and self-assessment

To fulfill the first research objective, this section and the next outline the findings about the awareness and state of CE implementation by the participants. All participants were asked an open question to establish if they were initially aware of the circular economy. Three of the participants had heard of the CE. One participant recently learned of the CE. Then two participants had never heard of the CE. The participants who had not heard of the CE were those in the shops that were visited in-person and are the smallest in size compared to the other participants.

Following the query about initial awareness, participants were asked to define the CE in their own words. The two participants that had not heard of CE had no definition to describe it as it was new to them. The remaining five participants had similar but also slightly different responses to their definition of CE. These responses ranged from a focus on waste reduction, to being about "closing the loop" and being self-sustaining. Others mentioned a focus on manufacturing, specifically about repurposing of materials and products and making items multi-use (connected to eco-design). One organization "includes" circularity within their environmental, social, governance (ESG) structure, therefore the participant defined circular economy in the same way. After their response, a more detailed version of the definition was shared from the researcher to build on the participant's knowledge and for context with the following interview questions (Appendix A).

4.1.2 Current implementation of CE in the Assessed Organizations

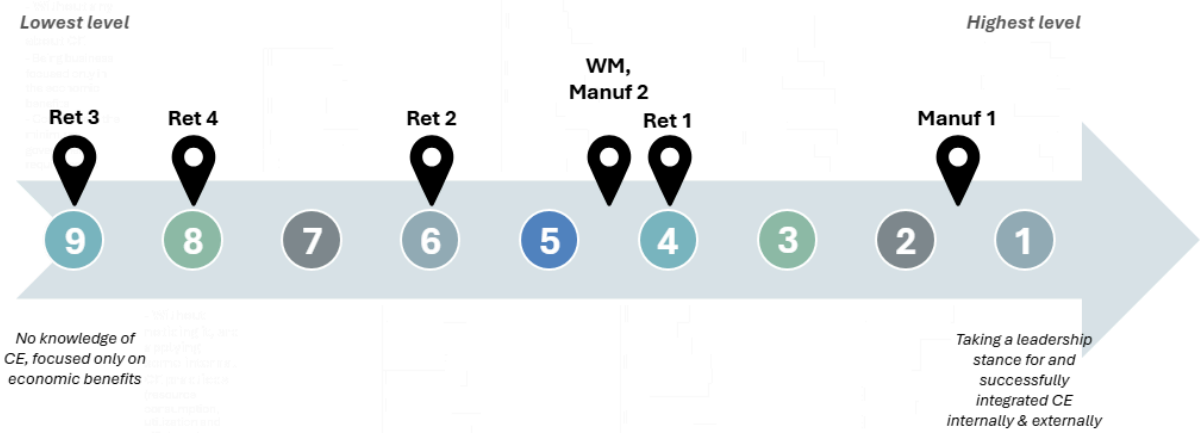
Each participant was asked to describe any CE actions their organization is currently undertaking. This open-ended question, without examples from the researcher, provided insights into existing CE activities, thereby establishing a valuable point-in-time baseline due to the lack of existing academic literature on this topic.

Notably, participant Ret 3 stated that CE actions were not considered necessary and was unaware of CE prior to the study. Participant Ret 4, however, manages the store's energy consumption, is transitioning to paper bags for customers instead of plastic, and reuses packaging in the back of the store, although they did not label these actions as part of a CE strategy. The remaining five participants described various activities supporting CE, which were thematically grouped from coding into categories such as business motivation and operations, end-of-life actions, limited eco-design, and limited R-strategies (reduce, reuse, recycle, and repair). Multiple participants confirmed that these products are entering general household waste streams, ultimately ending up in landfills or incinerated. Participant Manuf 2

mentioned their sustainability activities are currently being established, with most of their responses focusing on planned efforts. Additionally, four of the seven participants reported inquiries through their respective customer service points about product disposal, indicating a demand for more information.

Each participant was then asked to self-assess their organization's CE implementation on a scale, as described in the methods section (Appendices A and C). The scale, derived from existing literature, aimed to standardize responses across participants. As shown in Figure 3, responses ranged from one (no knowledge about CE) to between two (successfully integrated into business strategy) and one (taking a leadership stance for CE). Participants Ret 3 and Ret 4 were not asked this question due to their lack of prior understanding of CE. The responses illustrate the varied implementation of CE across industry stakeholders, without any meaningful clustering or grouping of ratings.

Figure 3: Current Organizational CE Implementation Level



4.2 Barriers to Implementing CE Strategies

Analyzing interview themes reveals barriers faced by manufacturers, retailers, and waste managers in implementing circular strategies in this industry. Many similarities were found with existing literature (Geissdoerfer et al., 2023), though not all barriers were encountered in this research. Additionally, some barriers specific to this industry, not

previously documented, were identified: stigma, product-specific issues, industry-specific challenges, and consumer behavior (coding scheme in Appendix D). Moreover, a second-order code related to the value chain, concerning a lack of collaboration among actors, was identified, expanding on Geissdoerfer et al's (2023) findings. The following paragraphs discuss the various codes present per theme.

The most frequently referenced and significant barrier identified was ***stigma***. This barrier arises from the product being perceived as controversial or sensitive, triggering feelings of shame and discomfort among parties in the value chain, such as consumers and waste managers, and contributing to the avoidance of both the products and the industry due to their taboo nature. All participants highlighted this barrier and emphasized its impact on initiating discussions beyond the product's intended use. Selected quotations from participants are listed in Figure 5.

The ***product*** theme is not specific to sex toys, rather about general issues when implementing CE with products. Firms face the challenge of designing eye-catching packaging to stand out on shelves, which often conflicts with sustainable packaging practices, such as using easily recyclable brown boxes with minimal labels. Additionally, there is a disconnect between packaging recycling symbols and actually waste pathways. The most significant barrier is that consumers do not pick up on these sustainability cues in retail locations, as the need for visually appealing packaging overshadows them. This product theme connects to the existing market theme about competition with an efficient linear system, as some firms try to compete directly alongside products and companies that are not selling sustainable products.

The next theme addresses ***industry*** characteristics, lack of awareness, and retailer limitations. Six of the seven participants from all stakeholder types reported minimal CE activity in the industry, with legal restrictions on advertising cited as a major barrier. Both

retailers and manufacturers reported difficulties in advertising across various channels such as social media, window displays, and commercials (see Figure 5 for quote). This issue is closely linked to the stigma surrounding CE but has become a systemic problem for retailers and manufacturers. Although four participants mentioned a few larger companies engaging in early-stage sustainability efforts, including CE strategies, these efforts remain limited. Other factors under this theme include: industry misconceptions about CE phrases versus their actual meaning, the industry is mainly comprised of SMEs, industry fragmentation, volume limits to doing CE strategies in-house impacting scalability, the industry is considered small in size compared to other industries, and the retailers operational volume is viewed as insignificant when compared to other business sizes.

The next theme is ***consumer behavior***, highlighted by two distinct codes. The first is the intention-action gap (Kilian & Mann, 2021), where consumers express a desire to buy sustainable items but do not follow through at the time of purchase. Participants acknowledged that sustainable sex toys are slightly more expensive than traditional products, highlighting consumer price sensitivity. This is connected to the code of affordability versus sustainability. The other code reflects participants' observations that people often ignore waste disposal instructions, leading to products ending up in general waste and landfills.

The last novel finding from this research is a code that aligns with the ***value chain*** category from Geissdoerfer et al. (2023): lack of collaboration. Participants noted no known collaboration with distributors, waste managers, or other parts of the value chain. While some collaboration exists between manufacturers and retailers, it is limited. Discussions about potential collaboration with other value chain members revealed that this concept was new to participants, highlighting its rarity and potential difficulty. One participant mentioned that distributors face significant challenges because large online retailers like Amazon “have

effectively replaced them." This is not the case in this industry, presenting a new barrier with implementing CE strategies.

For further analysis, Figure 5 presents the barriers matched to the MLP levels, with example quotes from the participants. This shows the top three barriers across all interview findings, whether new or identified by existing literature, and their intersection with socio-technical transition levels, offering insights into where these appear. Some barriers appeared with the same frequency, resulting in more than three barriers per level. Barriers identified as new in this research are highlighted in blue, while known barriers are in black.

Clearly, stigma manifests as a barrier at all three levels, showcasing the depth and ubiquitousness of the issue. At the socio-technical landscape (macro) level, the barriers following stigma include people being limited for cash (market) and country-specific regulatory differences (legal). At the socio-technical system (meso) level, industry codes of no CE observed or in early phase and inability to advertise are present. Additional frequent barriers at this level include profit motive (organizational) and the lack of required infrastructure to process material at waste (value chain). Lastly for niche-innovations (micro) level, small retailers have limited internal volume or capacity compared to other firms is a new theme (industry) from this research. In addition, it is expensive to do CE (financial) and staff lack information (organizational) round out the barriers for that level. Retailer limitations at the micro-level and affordability versus sustainability at the macro-level join the list of top barriers when assessing using the MLP. These insights show how intermingled the new and known barriers are, in addition to the pervasiveness of stigma at all levels.

Figure 4: Total of Tops Codes, New and Known about Barriers to CE

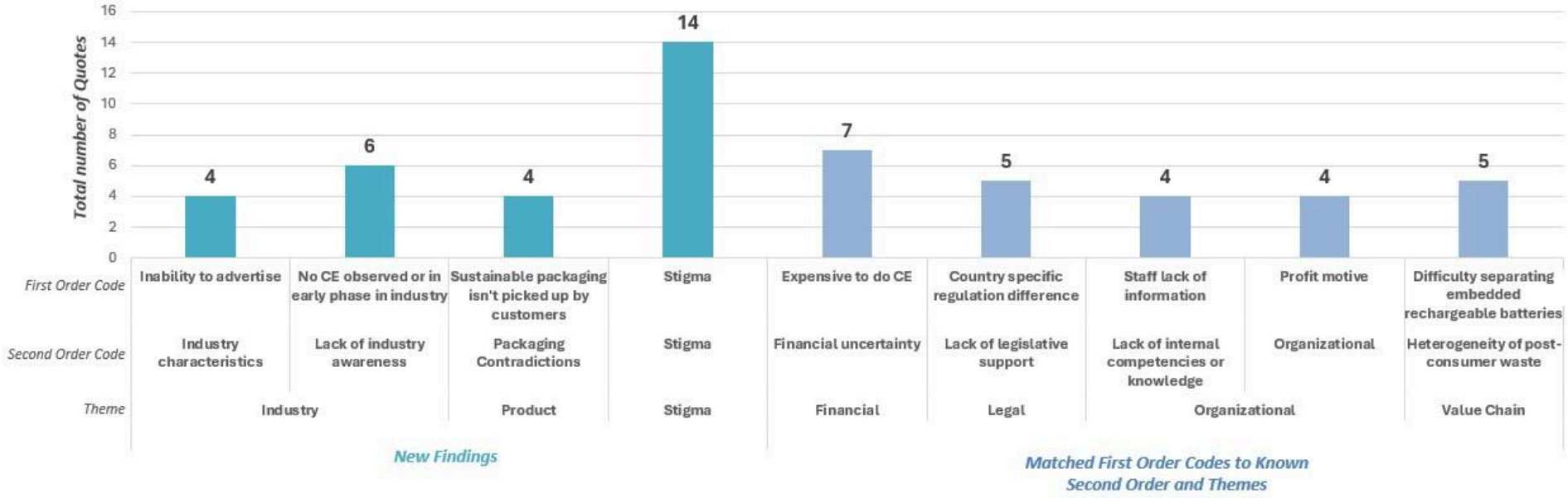


Figure 5: Example Quotes per Barrier, Aligned with MLP Level

MLP Level	Barriers (**Theme:** Second Order Code - *First Order Code*)	Example Quote from Interviews
Socio-technical landscape (macro) *General society (including those who do not purchase these products), government*	**Stigma:** Stigma - *Stigma*	*"Some people are ashamed to come in. Also with the way people are raised where sex is 'dirty.'"*
	Market: Affordability vs sustainability - *People are limited for cash*	*"... the consumer is very stretched for cash and they don't have a lot of money… I think as people have less income, the willingness to pay more for something [decreases]."*
	Legal: Lack of legislative support - *Country specific regulation difference*	*"And right now we're working with a lot of [international] suppliers. But we have some, yeah, different ones. So we're working with like 10 biggest ones and they also have certification for things like recycled paper, FSC paper. And the smaller ones are really struggling also, regarding the whole Europe change in that, but because we need to know where the product comes from and where the material comes from and what is your tracking rate."*

Socio-technical system (meso) *Industry level, global value chain*	**Stigma**: Stigma - *Stigma*	*"… because it's a stigma... Because you can't advertise."*
	Industry: Lack of industry awareness - *No CE observed or in early phase in industry*	*"And I think the sexual wellness industry is really in the beginning state of it."*
	Organizational: Organizational - *Profit motive*	*"We assume that every company basically is motivated by profit…. rampant capitalism of manufacturers…"*
	Industry: Industry characteristics - *Inability to advertise*	*"And right now we're being banned again. So right now, we're moving back again to like the old industry that people think no, it is shocking. We don't want to see a sex toy. So right now, if you also look on our site, you see a lot of vibrators blurred so people will really have to click on it, "Are you sure you want to see this product?" Because it is an explicit product and then you can see it. So right now we're really in the struggle phase with advertisements and it's really hard on the Internet right now. Also on social media, Facebook X, Google."*
	Value Chain: Heterogeneity of post-consumer waste - *Lack of required infrastructure to process material at waste*	*"And then you have like, things like that [bioplastic-made product], you know, technically biodegradable, but is there a facility in the entire world that can handle it? No."*
Niche-innovations (micro) *Individual, product, or company-level*	**Stigma:** Stigma - *Stigma*	*"Right now in the [country], electric products should be delivered in supermarkets or in [department store] at the disposal parts, so you have to return it there. Yeah. And people think it is really like a barrier because I'm not gonna give my vibrator to like and to put it in the recycle bin… because it is still like an awkward point to send it back"*
	Financial: Financial uncertainty - *Expensive to do CE*	*"And everything we do, you know, from an environmental perspective or sustainability perspective comes at such a high financial cost for us, right? It's very expensive. So labor intensive, especially with recycling."*
	Organizational: Lack of internal competencies or knowledge - *Staff lack information*	*"... lack of education on the part of the recycling centers."*
	Industry: Retailers limitations - *Small retailers have limited operational volume or capacity compared to other firms*	*"I think those smaller companies really struggle with it because it is also next to their daily work and… 'OK what do I need to do for 2030 to reduce this, this, this?'"*
	Product: Packaging contradictions - *Sustainable packaging doesn't stand out on store shelves comparatively; simple design to enable easier recycling*	*"I looked around, I couldn't find them. And eventually I did, but it's because it's a tiny brown box on a shelf that's full of bright colors."*

4.3 Examples of Sex Toy Products and their Connection with CE

During the shop visits, the top three best sellers at each store were identified for the CE product analysis. This analysis aimed to identify shortcomings in product characteristics and information disclosure. The products are detailed in Appendix B. The assessment revealed consistent information across all products regarding material composition, package disposal symbols, and country of manufacture. Material compositions were consistently listed across the nine products, likely due to governmental requirements. Silicone was consistently mentioned across the products. It was clear most of them were rechargeable but explicit mention of the lithium-ion battery as a component was rare. Various plastics were also common; ABS is the most prevalent, utilized in all vibrators and one masturbator. Only one butt plug explicitly indicated its phthalate-free composition.

Eight out of nine assessed products provided information on packaging disposal. Two of the four vibrators were identified as Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS) compliant with the European Union Directive ("RoHS Directive…" 2022). The other two vibrators would be logical to also have this indication, however the symbol is not present on the packaging. Four products were found to be meeting standards set by the United Kingdom Conformity Assessed (UKCA) and included the symbol ("Using the UKCA marking," 2024). The UKCA applies to many products from pyrotechnics to radios to machinery; it is unclear what product area sex toys fall under. The presence of the CE (conformité européenne in French) symbol and crossed-through bin symbol on five items denotes compliance with European Union regulations. The CE symbol indicates the product can be sold within the European Economic Area (EEA), meeting the area's safety, health, and environmental protection standards ("CE marking…" 2021). Furthermore, the crossed-through bin symbol reminds consumers to dispose of electronic waste properly ("WEEE - what…" 2024).

Two packages featured the 01 PET symbol, indicating the use of polyethylene terephthalate, a widely recyclable material ("Consumer Guide…," 2021). Four packages displayed the 21 PAP symbol, representing plain paper packaging, also commonly recycled ("Consumer Guide to Recycling Codes," 2021). Moreover, two vibrators exhibited the French Triman logo, complying with French recycling guidelines (decree no. 2014-1577), while three items included Italian text adhering to decree no. 116 ("Labeling for packaging…" 2022), indicating international sales. Lastly, four products featured a general recycling symbol, with two also displaying other symbols and two lacking any additional symbols.

The research reveals a disparity in information provided for packaging recycling versus product waste processes at end-of-life. Most products omitted instructions for lithium-ion battery disposal, a potential oversight about environmental concerns. Surprisingly, one product lacked recyclable packaging, hinting at a regulatory gap despite its mid-range pricing. Accessing online manuals proved challenging, with only three found, posing a hurdle for consumers seeking guidance. Additionally, a 15-year guarantee advertised on the box was limited to specific countries, excluding the Netherlands where the shop is located. Material disclosures often overlooked electrical components and batteries, signaling a lack of comprehensive transparency.

Most CE elements were consistently missing across the nine products assessed and in all CE life cycle stages (Appendix E). Examples of key missing elements are sustainability on source of materials, materials and energy use in the manufacturing stage, social benefits, disposal at end of life, and product lifespan. One connection between this gap and the interviews is the country specific regulations and how/if firms meet those regulations. All of these products are being sold in the same country, however not all the same symbols were present across similar products, like vibrators. Generally, the lack of CE elements aligns with

the other interview findings about lack of social awareness, lack of demand, and lack of industry awareness.

4.4 Opportunities

As an open question at the end of the interviews, participants were asked what opportunities there may be to help transition the industry to use CE strategies. Including their insights with the product analysis, this addresses the final research objective to present opportunities for this industry to implement CE strategies. A number of themes were identified; overcoming stigma, learning from other industries, applying pressure to stakeholders, collaboration within the value chain, eco-design, recovery tactics, and government action.

Understandably, there must be consideration to the complex ***stigma barrier and how to potentially overcome it***. Some participants suggested, transparency and data-driven discussions are essential to take focus off what the products are used for. Public outreach and creative advertising (navigating around the inability to advertise) by companies can help address misconceptions and build societal trust

Learning from other industries was referenced several times to further CE activities in the industry. Tools like case studies or exposure at professional conferences could facilitate cross-industry learning and cooperation, creating space for those in the industry to adapt those tactics to their specific products and firm. A few participants expressed a desire for ***pressure*** to be applied from one stakeholder in the value chain to another, as they have seen it be an effective means of change in other cases. A specific suggestion is for manufacturers to pressure waste managers to ensure that materials can be effectively recycled within current waste streams.

As seen clearly with barriers, there is a need for ***collaboration across the value chain*** - beyond retailers and manufacturers to waste managers, distributors, and more. This

collaboration could have substantial benefits when trying to share the learnings mentioned above. The challenge presented with this is about who facilitates the collaboration as the overwhelming majority of the firms in the industry are SMEs and have limited capacity; creative forms of collaboration and organizing should be explored to determine the most effective structure and contribute to the CE.

Ecodesign is a clear area of opportunity for firms, as evidenced through the product analysis in particular. This includes consideration of the entire product lifecycle, clearly listing battery materials, disassembly and repair options, and sustainable sourcing of materials. Emphasizing product longevity, multifunctionality, and modularity can reduce waste and resource use. Effective ***recovery*** of products at end-of-life (EOL) depends on clear instructions from manufacturers and retailers on proper disposal methods, particularly for batteries.

Several participants mentioned ***government action*** that supports CE and this industry as a potential mechanism to encourage change and support the global value chain. One participant suggested specifically taxation as a potential mode, in addition to supportive regulation. As seen in the barriers, global collaboration is difficult due to regulatory differences, therefore global governmental collaboration is viewed as potentially beneficial. From the product analysis, regulation and enforcement of consistent product labeling can promote CE practices since there is current variability.

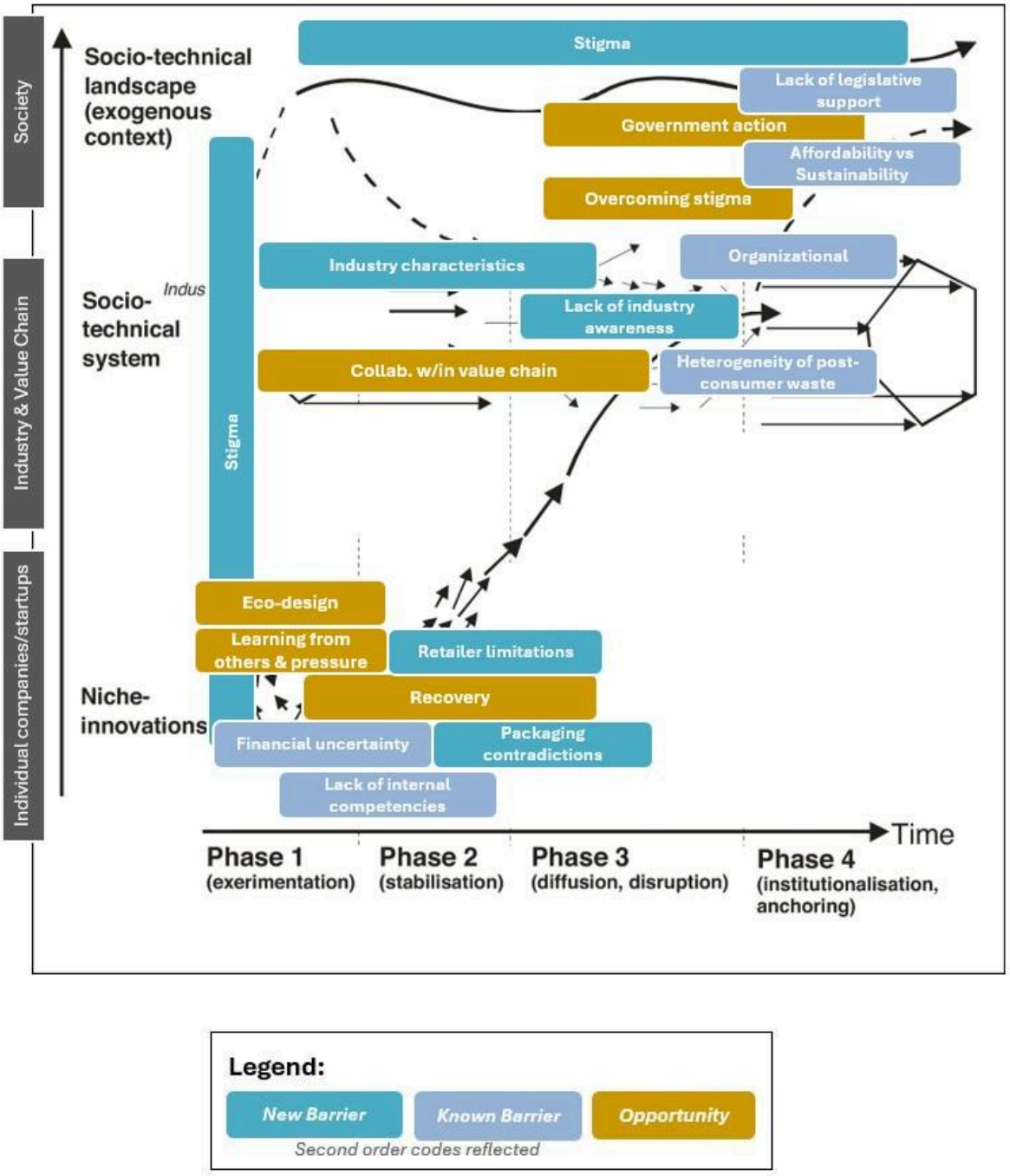
5.0 DISCUSSION

With the findings providing insight into the current state of the sex toy industry's circular economy efforts, the discussion shifts to understanding how they appear across the system supporting the industry. By understanding these barriers with the MLP, the academic community and stakeholders can better understand the barriers and opportunities across the

system, supporting a transition in the industry to use CE strategies. Below is a copy of the figure from the literature, modified to visualize the top barriers from Figure 5 and opportunities identified from the interviews (Figure 6). The information in Figure 6 utilizes the participant responses and supporting information from the product analysis, structured to capture micro–, meso-, and macro-levels. The section following Figure 6 focuses on one nuanced topic per MLP level, referencing the corresponding barriers and opportunities.

After completing the data analysis, the results were compared to those of Awana et al. (2024) to identify similarities and differences. Despite differing sampling criteria and only one firm in this study having sustainability in their value proposition, both studies identified several common barriers: lack of collaborations, sales challenges, consumer challenges, marketing and advertising difficulties, and sustainable packaging issues. Awana et al. (2024) also discussed advertising challenges, although not an inability to advertise, reinforcing that as a unique finding. Additionally, the findings revealed barriers stemming from private-actor policies, such as those enforced by major players like Google, X, and Meta. This issue connects closely with the stigma barrier as that is what influences the private-actor policy creating the restrictions. The persistence of stigma emerged as the most novel finding in this study, though it was anticipated.

Figure 6: Barriers and Opportunities Overlaid on MLP Informing Transition



5.1 Niche-innovation Level: Battery and Silicone Recovery

The interviews and data analysis revealed that embedded rechargeable lithium-ion batteries and silicone are the primary materials of concern. Although plastic was initially expected to be a major issue, it was consistently overshadowed by batteries and silicone in every interview and the product analysis. The focus on these materials/components directly

relates to the *product barrier* and aligns with identified *eco-design* and *recovery opportunities*. This issue is predominantly encountered at the niche-innovation (micro) level, starting with design and manufacturing at the firm level.

The product analysis revealed that batteries were not listed as components in each battery-operated item, nor were proper disposal methods indicated. Retailers emphasized the labor-intensive and costly process of removing embedded batteries from sex toys for responsible disposal. The waste manager highlighted the fire hazard posed by these batteries when they enter the facility through household waste, which is the common disposal route for sex toys. Krishna et al. (2024) stress the importance of properly recovering lithium-ion batteries for resource management, as demand for this material increases

Participants, except for the waste manager, quickly identified silicone as a frequently used material. The product analysis confirmed that two-thirds of the products contained silicone. Vu et al. (2023) highlight that silicone is a high-value material used in many products, but current reprocessing activities are limited and inefficient. For example of the material value, silica is also in solar panels and more research is occurring about the energy and water usage to create and reprocess the panels (Golroudbary, Lundström, & Wilson, 2024). Potential policy actions for these materials are discussed in section 5.4.

5.2 Socio-technical System Level: Retailer Operational Volume Dilemma

In four out of five remote interviews, a recurring dilemma about volume was identified, affecting the organization's operations and its potential to scale CE strategies. According to the retailer limitations code, two specific barriers were noted: *scalability limits with internal volume for CE strategies* and *small retailers have limited operational volume or capacity when compared to larger firms*. These barriers, categorized under the broader industry barrier, could be supported by *collaboration within the value chain* and *recovery*

opportunities. At the socio-technical system (meso) level, these challenges extend beyond individual retailers to the entire industry and value chain.

The small retailers have an internal capacity limit to operate recycling programs and manage the material sorting in order to dispose of these materials properly. For instance, one retailer has temporarily halted customer recycling intake due to exceeding their processing and storage capacity. They must handle recycling in-house because most products require disassembly before recycling, which waste managers do not provide. This in-house process incurs labor and space costs, making CE practices expensive. These limitations hinder the retailer's ability to scale, as expanding the service would necessitate additional resources. While this barrier presents at the niche-innovation (micro) level, there is an opportunity at the socio-technical system (meso) level through collaboration within the value chain (similar to the barrier identified by Awana et al., 2024), such as working with waste managers to develop a better recycling system to ensure continuous service.

However when small retailers attempt to implement CE strategies, such as proper waste disposal with waste managers, their efforts are often disregarded due to their low business volume by other stakeholders. Therefore, the retailers do not get attention or time with these stakeholders, creating another barrier. Even if small retailers scale internally and incur additional costs, there is no guarantee of collaboration from other stakeholders, illustrating the concept of the green prison (Pacheco, Dean, & Payne, 2010). One participant noted that manufacturers abroad are disincentivized to produce sustainable products for small retailers due to their lower volumes compared to existing designs. These issues create a complex dilemma, requiring some other type of intervention or commitment from value chain stakeholders to break the reinforcing loop.

5.3 Socio-technical Landscape Level: Navigating Stigma & Inclusion in Policy

The largest barrier consistently present across the findings is the importance and significance of stigma inhibiting adoption of CE strategies. This section addresses the *lack of legislative support* and *stigma barriers* using *governmental action* and *overcoming stigma opportunities* in conjunction. This is at the socio-technical landscape (macro) level since these present at the society level.

Existing research on overcoming stigma can provide guidance on addressing this barrier and facilitating the adoption of CE (see Piha et at., 2018). Stigma and fear of judgment are also significant factors in research on smoking (Woodrow et al., 2024) and the use of menstrual cups (Ajith & Rasheed, 2024), creating an instance to apply learnings from this study to those topics or vice versa. For instance, Ajith and Rasheed (2024) argue that individuals who are more open to challenging societal norms are more likely to use menstrual cups; this logic could similarly apply to the adoption of CE strategies with sex toys. However, their findings also underscore the strength of stigma, therefore a substantial barrier to behavioral change (Ajith & Rasheed, 2024).

When reviewing the findings in aggregate, the role of the government to support this industry takes a different angle than commonly present in research. Several participants emphasized the necessity for policies targeting materials or consumer products with shared components across multiple industries, rather than solely focusing on sex toys due to societal taboos surrounding public discussions about sex-related topics. This could be as simple as ensuring sex toys are included in the definition of goods and not excluded through a loophole, lack of explicitness, and/or ambiguity in policy phrasing. As seen in Forti, Baldé, and Kuehr (2018), an item like “personal massager” could potentially include vibrators (as suggested by a participant), however personal massager is not listed nor is a vibrator. When you search for items with the key terms of “motor” or “battery,” as they are key components of batteries, 16

and 21 instances of those words appear in that text respectively. However, 19 of those instances for battery all apply to clocks and wristwatches. While the motors referenced are self-contained, like those present in vibrators, they are limited to vacuums, toothbrushes, hair removing devices, motorcycles, and power tools (e.g. drills). In both instances, it is clear that sex toys like vibrators are not included through various types of interpretation. For policy action to include these items, it could be through clearly stating them or using broadly understandable language.

While there is some precedent for some sex toys to meet the regulation for specific packaging disposal symbols (like CE, UKCA, RoHS compliance for items considered “electronics” in some locations), this is limited to the packaging, with no regulation found about required product information for consumers about how to the responsibly dispose of the product itself. This is particularly concerning for the items with lithium-ion batteries as those should not be incinerated and are composed of increasingly precious materials ("WEEE - what…" 2024). It is also unclear whether there are similar regulations in place for silicone product packaging and products.Clear policies regarding the disposal of silicone products are crucial for managing and mitigating their environmental footprint, including when used in sex toys.

Governmental action regarding these products is unlikely to be prompted by public demand due to the strong stigma attached to them, but change at the societal level could be an enabler for societal opinions to change (Piha et al., 2018). Instead of waiting for public outcry, it may be prudent for the government to take proactive steps in the public interest. Concerns about the effectiveness of government regulation and inclusion of relevant stakeholders often deter support for such interventions in sustainability issues. However, given the limited likelihood of significant consumer engagement in this particular industry, government intervention may be necessary to catalyze change within the value chain.

Pacheco, Dean, & Payne (2010) suggest that collaboration between government and entrepreneurs can break free from the green prison by influencing legislation and introducing incentives at the macro-level.

The study has several implications for theory, namely the persistent stigma surrounding the subject, aligning with prior research on stigma in areas like smoking and menstrual cup use. The identification of both familiar and new barriers underscores the issue's complexity and contributes to theory. Despite variations in sampling, certain barriers mirrored those found by Awana et al (2024), reinforcing the presence of those barriers and across contexts. The unique finding of the inability to advertise emphasizes its significance as a barrier for this industry, connected to stigma. Additionally, the exemplification of the green prison concept confirms the presence of the challenge for firms implementing CE or sustainability strategies.

The practical implications range widely with many ideas for the industry stakeholders to consider, like implementing eco-design, learning from other industries, and addressing legal constraints such as advertising limitations. This study encourages enhanced recovery processes and policies for lithium-ion batteries and silicone to minimize environmental impact. Identification of the retailer volume challenge helps to frame the issue and overcome it through collaboration. Clear communication of instances where these products are included in policy and advocating for proactive policy measures will also foster change in the industry in support of CE. Lastly, collaboration between government and entrepreneurs to break free from the green prison has the potential to have a lasting positive impact for the industry and climate action efforts.

5.4 Limitations

This study has several limitations. Firstly, due to time constraints and a low response rate from interviewees, only one waste manager was interviewed, limiting insights from this stakeholder group. Additionally, one company did not respond to follow-up questions, reducing available information. A larger-scale quantitative study would enhance the generalizability of findings. Furthermore, the geographic distribution of participants is not fully representative of all relevant markets. Limited availability of user manuals hampers detailed product analysis, hindering exploration of eco-design aspects and manufacturer-recommended waste processes. Finally, the rating on the CE scale by participants and the CE product checklist were simplified, lacking the application of detailed tools for this purpose.

6.0 CONCLUSION

This research provides a comprehensive understanding of the current awareness and state of circular economy (CE) implementation among participants in the sex toy industry. Nearly half of the participants were already familiar with CE concepts, while the remainder encountered it for the first time through this study. Despite varying levels of awareness, almost all organizations were engaged in CE activities, with five participants rating their implementation efforts at six or higher on the scale. The research identifies and verifies various established obstacles to the implementation of CE, including those related to the market, legal framework, finances, value chain, and organizational structure. Additionally, it uncovers novel barriers concerning societal stigma, industry-specific challenges, product challenges, and consumer behavior. Among these, societal stigma emerges as the most prominent impediment. Through product analysis, the research highlights eco-design as a

significant area of opportunity. Currently, packaging often provides minimal information regarding disposal, underscoring a need for improvement in this aspect.

Several opportunities for enhancing CE strategies in the industry have been identified. These include government intervention, overcoming stigma, adopting eco-design principles, fostering collaboration across the value chain, learning from other industries, and developing effective recovery strategies. These opportunities span across the socio-technical system, as identified using the multi-level perspective, and present a multifaceted approach to advancing CE implementation. The sex toy industry offers a good example of the intricacies firms face when implementing CE strategies, particularly in the larger context consumer products made of the same materials, like menstrual cups or pet toys. The theoretical implications are new empirical data that support the existing research and add to the barrier discussions of SMEs, stigmatized industries, and industries recently starting to leverage circular economy strategies, supporting a sustainable transition.

6.1 Future Research

Future research could focus on conducting a comprehensive life cycle assessment for different types of sex toys to measure their environmental impacts accurately. The industry and broader society would also benefit from a precise quantification of waste generated and resources utilized throughout the production and consumption stages of sex toys. Additionally, further understanding consumer perspectives, behavior, and reflections on overcoming stigma can support the inclusion of circular economy practices. Research supporting cross-industry collaboration (based on shared material types across industries, like silicone or lithium-ion batteries) with international governmental stakeholders for policies supporting CE to decrease national policy variability would be helpful.

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APPENDIX

Appendix A: Interview Guides

Waste Managers Interview Guide

Organizational information:

- Please describe your business's relationship to the adult sex toy industry (stakeholder identification).
- Company size with employee count?
- Company size with where they operate (location served)?
- What is your main product or service?
- What are the most frequent materials you process or work with?

Research questions:

- Have you heard about the circular economy? If yes, could you describe it in your own words? *(establish a definition)*
    - If no, clarify: "CE is an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production, distribution and consumption processes" (Kirchherr et al., 2017). This is a change from the dominant linear economy to a circular one by closing the resource loops (creating a circle). This includes tactics of maintenance, reuse, repair, remanufacture, recycling, long-lasting design, refurbishing, business model innovation, avoiding impacts on raw material sourcing and more (Geissdoerfer et al., 2017; Chrispim et al., 2022). It can occur through the stages of the product life cycle - take, make, distribute, use, and recovery (Sandoval, 2023). It aims to support environmental quality, economic prosperity, and social equity (Chrispim et al., 2022).

    - For our discussion, I think it is appropriate to focus on the recovery stage of the product life cycle based on your business type.
- How would you rate your **company** currently in its adoption/implementation of CE with the organization? – *show slide for visual aid, Appendix C*
- Does your **company** currently do any waste management with sex toys?
    - If yes, what does that entail?
    - If not, why not?
- What barriers do you observe or foresee if your **company** were to support/ implement more circular economy tactics with sex toys at the recovery stage (EOL)?
    - *Possible follow ups: concerns about recovery? Concerns about supplying the "take" and "make" stages after recovery? Technology/ability to process these materials alongside existing material waste streams? Concerns with handling these types of products or volume?*
- Based on your knowledge, how would you describe the current state of the sex toy **industry** with implementing circular economy concepts?
    - Do you think there are problems in specific areas and if so, where?
- Adjacently, what are some barriers that come to mind with **broader society** (like government, general public, etc) in order to implement more circular economy tactics with sex toys?
- What opportunities (ideas, suggestions, etc) do you think there may be to transition the industry to be more circular?
- Is there anything you would like to add based on our discussion today (final comment)?

Retailers and Manufacturers Interview Guide

Organizational information:

- Please describe your business's relationship to the adult sex toy industry (stakeholder identification). Like a manufacturer, retailer, etc.
- Company size with employee count?
- Company size with where they are sold (location served)?
- What kinds of products do you sell?
- What is your main product or service?
- What kinds of materials are they made of?

Research questions:

- Have you heard about the circular economy? If yes, could you describe it in your own words? *(establish a definition)*
    - If no/clarify - "CE is an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production, distribution and consumption processes" (Kirchherr et al., 2017). This is a change from the dominant linear economy to a circular one by closing the resource loops (creating a circle). This includes tactics of maintenance, reuse, repair, remanufacture, recycling, long-lasting design, refurbishing, business model innovation, avoiding impacts on raw material sourcing and more (Geissdoerfer et al., 2017; Chrispim et al., 2022). It can occur through the stages of the product life cycle - take, make, distribute, use, and recovery (Sandoval, 2023). It aims to support environmental quality, economic prosperity, and social equity (Chrispim et al., 2022).

    - For our discussion, I think it is appropriate to focus on the take, make, and distribute stages of the product life cycle based on your business type.
- Is your **company** currently doing any work to incorporate circular practices into the take, make, distribute phases of the product life cycle?
    - If so, please describe a bit about this work.
    - If not, why not?
    - *Possible follow up - doing any consumer awareness/education about what to do at EOL and how is that going?*
- How would you rate your **company** currently in its adoption/implementation of CE with the organization? – *show slide for visual aid, Appendix C*
- How would you describe the current state of the sex toy **industry** with implementing circular economy concepts?
    - Do you think there are problems in specific areas?
- Adjacently, what are some barriers that come to mind with **broader society** (like other waste management/retailers, government, general public, etc) in order to implement more circular economy concepts or practices?
- What opportunities (ideas, suggestions, etc) do you think there may be across the stakeholders to transition the industry to be more circular?
- Is there anything you would like to add based on our discussion today (final comment)?

Appendix B: Information Sheet and Consent Form

INFORMATION SHEET

Sustainable Entrepreneurship Project (master thesis):
WHAT ARE THE BARRIERS AND OPPORTUNITIES TO TRANSITION THE SEX TOY INDUSTRY TO BE CIRCULAR?

Dear participant,

Thank you for your interest in participating in this research. This letter explains what the research entails and how the research will be conducted. Please take time to read the following information carefully. If any information is not clear kindly ask questions using the contact details of the researchers provided at the end of this letter.

WHAT THIS STUDY IS ABOUT?

- This study is being conducted to understand the current barriers to transition the adult sex toy industry to be circular. About ten participants are being asked to participate.
- You are asked to participate in this study as a stakeholder of the adult sex toy industry, either now or in the future.
- This research is not funded by any other party.

WHAT DOES PARTICIPATION INVOLVE?

- Your participation involves one online interview, no longer than 30 to 60 minutes in length.

DO YOU HAVE TO PARTICIPATE?

- You are welcome to participate but it is not required. Your participation is strictly voluntary and consent is required.
- If you decide to participate, you may withdraw your participation up until 10 May 2024 by informing the researcher via email, without needing to explain and without consequences to you. In the event this occurs, all the data provided by you will be destroyed. Please note that once the data is being analyzed and/or results documented it may not be possible to remove all your data from the study.

ARE THERE ANY RISKS IN PARTICIPATING?

- There are no risks in participating in this study.

ARE THERE ANY BENEFITS IN PARTICIPATING?

- There are no direct benefits of participating in the study. The research hopes to contribute to further knowledge on the topics of circularity, industry transition and sustainable entrepreneurship.

HOW WILL INFORMATION YOU PROVIDE BE RECORDED, STORED AND PROTECTED?

- The interviews will be recorded and transcribed for coding and analysis purposes. None of your individual information will be disclosed to anyone outside of the researcher.

- The information provided will only be used for this study and the thesis directly related to this.
- The data from this study (consent forms, recordings, interview transcripts) will be retained on the University of Groningen Google Drive server for the maximum of 5 years, in correspondence with the university GDPR legislation.

WHAT WILL HAPPEN TO THE RESULTS OF THE STUDY?

- The information provided will be used in conjunction with other participant data for thesis research and paper for a Sustainable Entrepreneurship master's program. A research translation will also be created about the findings. The thesis research and findings will be presented at the Campus Fryslan Conference. The document will be uploaded and available through the UG library catalogue.

ETHICAL APPROVAL

- This research study has obtained ethical approval from the Campus Fryslân Ethics Committee.
- The researcher will uphold themselves to relevant ethical standards.

INFORMED CONSENT FORM

- Please sign the informed consent form below. This means you have the intention to participate and you may withdraw at any time.

WHO SHOULD YOU CONTACT FOR FURTHER INFORMATION?

Contact Megan Nation, researcher of this study, at m.k.nation@student.rug.nl.
The academic supervisor of this study is Mariana Cardoso Chrispim, m.cardoso.chrispim@rug.nl.

INFORMED CONSENT FORM

Study Title: *WHAT ARE THE BARRIERS AND OPPORTUNITIES TO TRANSITION THE SEX TOY INDUSTRY TO BE CIRCULAR?*

Name participant:

Assessment

- I have read the information sheet and was able to ask any additional questions to the researcher.
- I understand I may ask questions about the study at any time.
- I understand I have the right to withdraw from the study up to 10 May 2024 without giving a reason.
- I understand that at any time I can refuse to answer any question without any consequences.
- I understand that I will not benefit directly from participating in this research.

Confidentiality and Data Use

- I understand that none of my individual information will be disclosed to anyone outside the study team and my name will not be published.
- I understand that the information provided will be used only for this research and publications directly related to this research project.

- I understand that data (consent forms, recordings, interview transcripts) will be retained on the University of Groningen Google Drive for the maximum of 5 years, in correspondence with the university GDPR legislation.

Future involvement (circle)

- I wish to receive a copy of the scientific output of the project. YES NO
- I consent to be re-contacted for participating in future studies. YES NO

Having read and understood all the above, I agree to participate in the research study:
YES / NO

Date

Signature

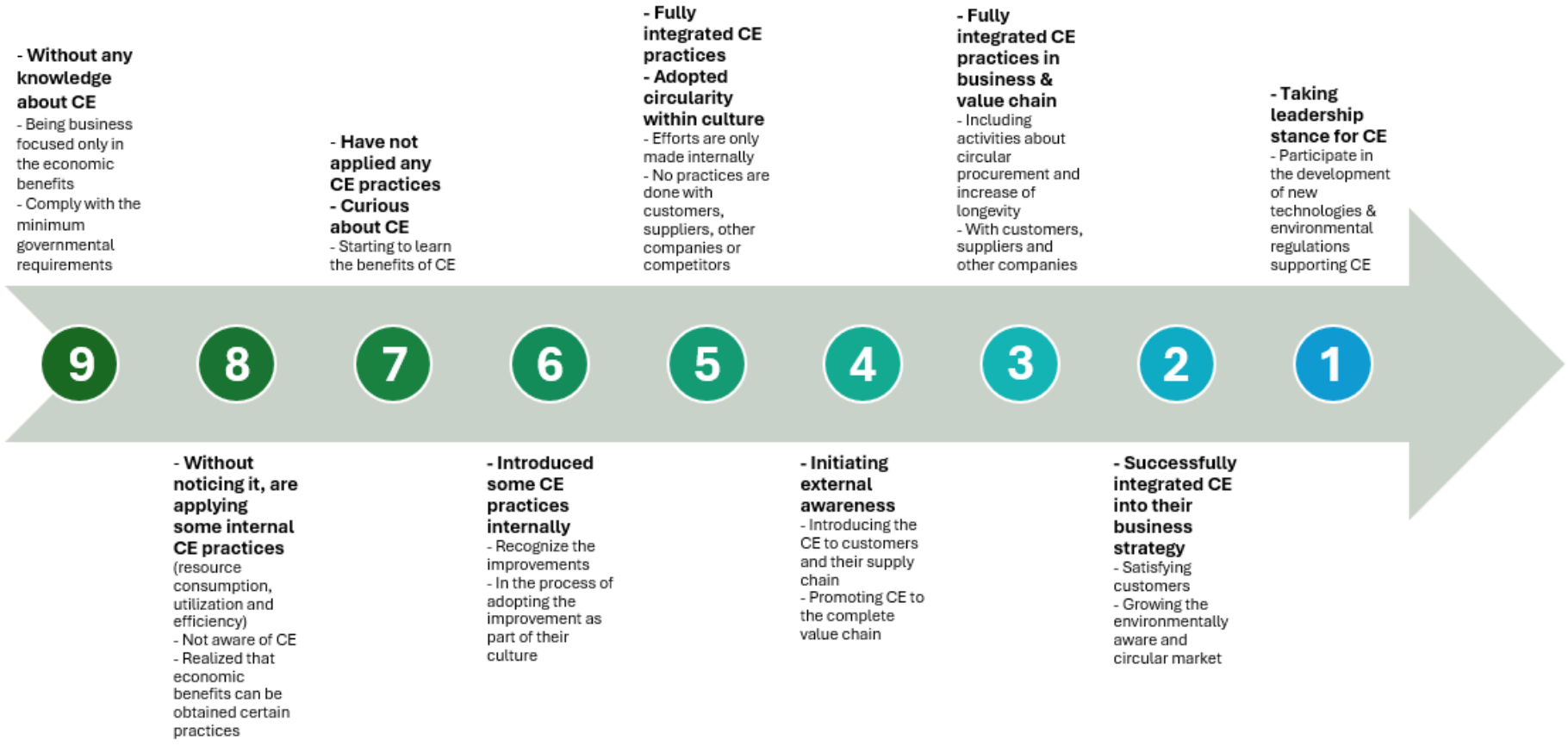
To be filled in by the researcher

- I declare that I have thoroughly informed the research participant about the research study and answered any remaining questions to the best of my knowledge.
- I agree that this person participates in the research study.

Date

Signature

Appendix C: CE Scale used in interviews



Lowest level *Highest level*

Appendix D: Table of Interview Coding to Themes based on Findings

First Order Code	Second Order Code	Theme
• Stigma (controversial, sensitive, shame, discomfort)	Stigma	Stigma
• Changing packaging goes against sustainability values • Disconnect between symbols on packages and actual waste pathways • Sustainable packaging doesn't stand out on store shelves comparatively; simple design to enable easier recycling	Packaging Contradictions	Product
• Recycled plastic quality and price issues • Silicone challenges make, recycle and degradation	Recycled materials issues	
• Limited awareness of CE definitions and strategies • Industry is doing a little sustainability/CE or in beginning stages • Larger companies in industry started the work, but not yet beyond those few companies	Lack of industry awareness	Industry
• Industry considered small • Largely comprised of SMEs • Industry fragmented • Inability to advertise	Industry characteristics	
• Small retailers have limited operational volume or capacity compared to other firms • Scalability limits with operational volume for CE strategies • Shopping experience is commonly quick (impacting consumer experience)	Retailer limitations	
• No collaboration known beyond some retailers/manufacturers • No collaboration with distributors • No collaboration with waste managers	Lack of collaboration	Value Chain
• Intention-action gap at purchase • People don't pay attention or follow waste instructions; goes to landfill	Consumer Behavior	Consumer Behavior
• Expensive to do CE	Financial uncertainty	Financial

• Considered biohazard legally • Country specific regulation difference • Governmental resistance to sex topics • Legislation catch up for CE	Lack of legislative support	Legal
• Intellectual property implications with design	Restrictive product regulations	
• Consumer price sensitivity and understanding • People are limited for cash • People love cheap products	Affordability vs sustainability	Market
• Commercial viability • Manuf abroad not incentivized to create new process • Must be an amazing product regardless of CE	Competition with efficient linear system	
• No customer inquiries for CE products	Lack of consumer demand	
• Consumers lack of information after use phase • Public not focused on/aware of CE generally	Lack of social awareness	
• Following governmental regulation about sustainability • Staff lack information	Lack of internal competencies or knowledge	Organizational
• Profit motive	Organizational	
• Embedded rechargeable batteries • Lack of required infrastructure process material at waste • Many materials used; complex at waste • Material rejected at WM due to product type	Heterogeneity of post-consumer waste	Value Chain
• No destination for reuse • Send back to manuf at EOL	Immature reverse logistics systems	

Appendix E: CE Product Analysis

Legend ✓ Found and fulfills the criteria ✗ Found and does not fulfill the criteria 🔍 Not found

Life Cycle Stage	Criteria	Vibrator			Insertable Vibrator	Masturbators		Anal Plug		Dildo
		Product 1	**Product 2**	**Product 3**	**Product 4**	**Product 5**	**Product 6**	**Product 7**	**Product 8**	**Product 9**
N/A	**Current Price**	€ 34.99	€ 59.99	€ 79.95	€39.99	€ 49.95	€ 129.99	€ 11.99	€ 24.95	€ 37.99
Take / Make	**Sustainably sourced product materials?**	🔍	🔍	🔍	🔍	🔍	🔍	🔍	🔍	🔍
Take / Make	**Sustainably sourced packaging materials?**	🔍	🔍	🔍	🔍	🔍	🔍	🔍	🔍	🔍
Make	**Lists material composition Anything about exclusion of unsafe or hazardous materials?**	Body-friendly silicone, rechargeable li-ion battery, magnetic charger Material: silicone, ABS	Body-friendly silicone; Material: Silicone, ABS, charger	Silicone, rechargeable, ABS	Silicone, rechargeable	Tube made of PP Plastic, Sleeve made of TPR	TPE, ABS, silicone with a polyurethane coating, Non-removable li-ion battery, cable included	Aluminum body, acrylic stone (base), Phthalate free: yes	"Main composition: Silicone:	Material: PVC
Make	**Country made in listed (Y/N)**	✓	✓	✓	✓	✓	✓	✓	✓	✓

Make	**Anything about being made with fewer materials or energy?**									
Take / Make / Distribute	**Any business social or ethical benefits listed?**									
Take / Make / Distribute	**Anything about carbon offsets or other similar support of sustainable orgs?**									
Take / Make / Distribute / Recover	**Any sustainability (or greenwashing) claims at all?** *Desired answer is not present, therefore fulfills criteria.*	✓ No, meets criteria	✓ No, meets criteria	✓ No, meets criteria	✓ No, meets criteria	✓ No, meets criteria	✓ No, meets criteria	✓ No, meets criteria	✓ No, meets criteria	✓ No, meets criteria
Use	**Recycling icon and type listed**	01 PET, 21 PAP, CE logo, UKCA logo, crossed-through bin, booklet with "i", Triman logo & sorting instruction for France, text note to "Separate waste collection: check the	01 PET, 21 PAP, booklet with "i", UKCA, CE, crossed-through bin, Triman logo & sorting instruction, text note to "Separate waste collection: check the regulations of your	Crossed-through bin, CE, general recycle symbol, RoHS Compliant (2002/95/EC)	Crossed-through bin, UKCA, please recycle symbol, CE, RoHS compliant		CE, UKCA, crossed-through bin, 21 PAP triangle, text note to "Separate waste collection: check the regulations of your municipality" in Italian	Recycle symbol and "please recycle these package materials"	21 PAP recycle symbol	General recycle symbol

		regulations of your municipality" in Italian	municipality" in Italian							
Use	**How to repair or get repair support?**	✗*	✗*	✗	✗	✗	✗	✗	✗	✗
Use	**Recyclable packaging?**	✓	✓	✓	✓	✓	✓	✓	✓	✓ only product with plastic packaging
Use	**Anything about expected product lifespan?**	✗	✗	✗	✗	✗	✗	✗	✗	✗
Use	**Multi-function? (Does what multiple individual items do)**	✗	✗	✓	✗	✗	✗	✗	✗	✗
Use	**Anything about being modular?**	✗	✗	✗	✗	✗	✗	✗	✗	✗
Use / Recover	**How to disassemble?**	✗	✗	✗	✗	✗	✗	✗	✗	N/A
Recover	**Direction about what to do at end-of-life of product**	✗	✗	✗	✗	✗	✗	✗	✗	✗
Recover	**What to do with the battery at EOL?**	✓ in manual	✓ in manual	✗	✗	N/A	✗	N/A	N/A	N/A

N/A	**Able to find warranty or manual online?**	✓	✓	✗	✗	✓ only about how to use and clean	✗	N/A	✗	N/A

* Under limitation of liability: “Non-compliance with this manual/ Improper use/ Unauthorised alterations/ Technical modifications/Use of unapproved spare parts/Use of unapproved accessories” – does not support repair

Appendix F: Consistently Missing CE Elements from Product Packaging

- Sustainably sourced product materials
- Sustainably sourced package materials
- Manufactured with fewer materials or energy?
- Is it multi-function/perform what multiple items do?
- Anything about being modular? *(N/A for a two)*
- Any business social or ethical benefits?
- Anything about carbon offsets or other similar support of other sustainable organizations (like partnerships or certifications)
- Expected product lifespan
- How to disassemble *(N/A for three)*
- How to repair or get repair support
- EOL instructions
- What to do with the battery at EOL

Appendix G: Transcripts

Link to transcripts