PolyCE

Post-Consumer High-tech Recycled Polymers for a Circular Economy

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Lead Beneficiary: UNU

Lead Author: Violeta Nikolova, United Nations University
Elena D'Angelo, United Nations University
Elise Vermeersch, United Nations University
Johanna Emmerich, Technical University Berlin
Franziska Maisel, Technical University Berlin
Rebecca Colley-Jones, University of Northampton
Ruth Copeland-Phillips, University of Northampton

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Lead Author Contact: nikolova@vie.unu.edu

Table of Contents

1 Introduction.

An important component of the PolyCE project's mandate is to promote the benefits of circular business models for all actors in the plastics value chain and beyond. The research findings stemming from PolyCE's Work Packages 1 and 9 suggest a slow but positive trend of transition from linear towards Circular Economy for businesses and consumers in the electronics sector. These findings are synthesised and used as main points of reference in the argumentation and conclusions in the following chapters.

This PolyCE deliverable 1.3 presents a cumulative value chain map of current level of circularity in the plastics value chain, with a specific focus on the electrical and electronic equipment (EEE) sector. It is a single point of reference for small and large businesses on latest insights into consumer preferences, advancements and lessons learned from businesses who are embracing circularity and disrupting the linear status quo. In addition, it includes a "Sales Pitch" promotional infographic that showcases the benefits for adopting post-consumer recycled (PCR) plastics into business operations, which entails persuasive arguments to sell the concept of using more recycled plastics in new applications for internal communication purposes. It is a tool to translate academic research and data into business language and to transform research findings into practical business sales terms.

Targeting businesses, but also governments, civil society and policy makers, the following research is the result of the cumulative work of the PolyCE project partners across all work packages and it is the ultimate business insight and knowledge source on why investing into PCR plastics makes business sense from an environmental, economic, political, social and business perspective.

The following chapter 2 presents short definitions of key terms used in the next chapters of the deliverable.

Chapter 3, co-drafted by the United Nations University examines the consumer perspective on the benefits and risks of adopting circular consumption models. It provides insight into consumer adoption levels of different new and disrupting consumer practices, which are part of the sharing and circular economies. Additionally, it includes tips for business on how to capture and benefit from this new emerging consumer market, and related recommendations for improving the level of engagement of consumers with this circular consumption trend. Conclusions related to the potential of dematerialisation of EEE based on the aforementioned new consumption practices and their integration into existing systems are included.

Chapter 3, co-drafted by the University of Northampton captures essential insight into circular business models, their application in practice and the lessons learned from companies who are on their journey towards circularity. Four case studies based on direct input from major OEMs (Philips, Whirlpool, HP, Dell) and a leading plastics recycler company (MGG Polymers) during a PolyCE-led stakeholder consultation, are included into a cumulative circularity matrix. Conclusions from these case studies provide insight into the applicability of circularity into business processes: an analysis of internal company policies enabling the adoption of circular practices, featuring a step-by-step guidance.

The last chapter, co-drafted by the Technical University of Berlin, provides a valuable SWOT and PESTLE analyses shaping a thorough business case for the integration of PCR plastics into new electric or electronic products. The research examines the enabling factors for including more recycled plastics into new electronic applications, considering internal and external aspects such as political winds and technical developments, and provides a step-by-step guidance for companies considering to start this journey. A 'Sales Pitch' infographic includes the essence of the deliverable: a compilation of business arguments and relevant data showcasing the benefits to be considered when choosing this path. The sales Pitch can be a tool to be presented to management of an OEM or for other suitable communication formats.

Overall the value chain map of circularity presented in this research is providing an overarching perspective on the market potential of circularity from a point of view of consumers, small business, OEMs, governments and the general public. It is a source of insight into the current level of adoption of the Circular Economy among businesses and consumers and a guidance towards strengthening, supporting and incentivising sustainable trends in our European economy and society.

2 Definitions.

2.1 Circular economy.

Kirchherr et. al. define the Circular Economy as “an economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.”

The Ellen MacArthur Foundation’s definition of the Circular Economy is providing an even more general definition, which encompasses a ”systemic approach to economic development designed to benefit businesses, society, and the environment. In contrast to the ‘take-make-waste’ linear model, a circular economy is regenerative by design and aims to gradually decouple growth from the consumption of finite resources.”

2.2 Collaborative economy.

Closely related and a by-product of the Circular Economy is the so-called “collaborative” or “sharing” economy. The Cambridge English Dictionary defines it as “an economic system that is based on people sharing possessions and services, either for free or for payment, usually using the internet to organize this.” (Cambridge dictionary, 2020)

The collaborative economy is characterised by a great variety of business models and spans multiple sectors each having its own market characteristics, which makes a single definition difficult to reach. However, a common element in the majority of business models is the use of under-utilised assets for the extraction of economic benefits (Petropoulos, 2017).

Overall, collaborative consumption depends upon the customer self-seeking, and, at the same time, it offers several communities-, financial- and surrounding- based benefits.

2.3 Dematerialisation.

Dematerialisation is delivering the same product or service using a percentage or none of the mass or material types. It is valuing what the product does rather than valuing the product itself. There are a few pathways to dematerialise a product:

Digitise – sell the product electronically or virtually

Servitise – sell the utility of the product as a service
Reduction - absolute or relative reduction in the quantity or type of materials used and/or the quantity of waste generated in the production of a unit of economic output

A simple example of product dematerialisation is the transition from purchase of equipment to provide lighting to lighting as a service. Dematerialisation may provide reductions in cost of goods sold, inventory, manufacturing time or negative environmental impacts.

2.4 Circular Consumption Models.

In line with the PolyCE project, six types of circular consumption models supporting plastic dematerialization and/or integration of PCR plastics in EEE have been defined and studied to understand how consumption can contribute to the CE. The below table provides working definitions of circular consumption models as identified in the framework of this report.

Table 1: Circular Consumption Models: Definitions

Consumption Model	Definition
Reuse B2C C2C	The consumer action of opting for a second hand / used EEE device. Resource reuse means using a discarded product, component or material for the same function it originally served, with minimal processing (Circular Economy Practical Guide, 2020) Example: https://www.ereuse.org/
Repair B2C C2C	The consumer action of fixing a specified fault in an object that is a waste or a product and/or replacing defective components, in order to make the waste or product a fully functional product to be used for its originally intended purpose (UNU elaboration based on Basel Convention Secretariat, 2016) Example: https://repaircafe.org/en/
Buy remanufactured B2C	The consumer action of opting for a product that has been remanufactured. Remanufacturing is the process of recovering, disassembling, repairing and sanitizing components for resale at “new product” performance, quality and specifications. Remanufactured products or parts should be considered “like new” (Circular Economy Practical Guide, 2020)

Buy refurbished B2C	The consumer action of opting for a product that has been refurbished. Refurbishing is the process of returning a product to good working condition by replacing or repairing major components that are faulty or close to failure, and making 'cosmetic' changes to update the appearance of a product, such as cleaning, changing fabric, painting or refinishing. Accordingly, the performance may be less than as-new[1] (EMF, 2013) Example: https://www.backmarket.com/
Lease / Rent / Pay-per-use B2C	The consumer action of subscribing to a service compensation model, in which the customer pays for continuous access to a product over an agreed period. Product manufacturers typically maintain ownership of the product and are responsible for delivery, maintenance and take-back. (Circular Economy Practical Guide, 2020) Example: https://www.grover.com/de-de
Barter B2C C2C	The consumer action of participating in a non-monetary product exchange scheme, whereby consumers exchange (usually old or repaired) products amongst each. Additionally there are trade-in schemes hosted by the manufacturers themselves, whereby the consumers exchange an old device (usually a smartphone) for a new one, while being reimbursed for the price of the old device. Examples: https://www.samsung.com/de/offer/trade-in/ https://www.akkutauschen.de/index.php?section=service https://www.ebay-kleinanzeigen.de/s-tauschen/smartphone/k0c273 https://www.handyverkauf.net/tauschen

[1] Refurbished products may have different grades, and the price may vary accordingly. A refurbished grade denotes the quality of a refurbished product or device. Refurbished products are graded depending on how many cosmetic imperfections they have (e.g. scratches, scuffs, and other marks) as well as how much the product has been used by its previous owner and what packaging it comes in. Consumers can usually select among three main grades (A, B, C etc.), from best quality with near-mint conditions and very little signs of previous use, to the lowest quality, 100% in working order but with more signs and imperfections.

2.5 Circular Economy Business Models.

The concept of Circular Economy (CE) can provide companies with an opportunity to transform the way they create value. Circular business strategies can pave a way towards production and consumption patterns that enable long-lasting sustainability. In a CE, companies that implement circular business models (CBM) play an important role. In line with the PolyCE Project five different types of dematerialization models that have been categorized to understand alternative business model types (Emmerich, 2017). A special focus has been on the integration of PCR plastics in the company's' portfolio:

Long-life Model.

The Long- life Model describes the production and sales of high-quality long-lasting products, which retain extensive value after use by the consumer so that reuse or refurbishment is likely (Bakker et al. 2014). It is the CEBM that is based on traditional linear ownership models, where manufacturers design and produce a product line and the consumer gains possession by purchasing the product. It is included as CEBM because the product is considered a quality functional product and has been designed to be recycled, repaired or refurbished.

ReValue Model.

The ReValue model represents any business model which reuses either whole products, component parts or materials. The ReValue model therefore encompasses a large variety of possible business models, including re-use, refurbishment, repair and recycling (Laubscher, Marinelli 2014). Material flows are treated as raw materials into new production circles by giving them a new value.

Modularity Model.

Adopters of a modularity model contribute to the CE concept by prolonging the lifetime of a product through a more modular design. Modular devices are defined as containing modules which are structurally independent elements or sub-assemblies with clearly defined interfaces (Kashkoush, El Maraghy 2016). By easily replacing, or repairing, parts, or enabling a product upgrade, costumers are motivated to keep using products for longer. The need, or desire, for early purchase of a new, replacement, device before the product has reached its ultimate end-of-life is thereby reduced (Colley-Jones et al. 2019). Replacing only certain parts of an electronic device is a step towards balancing out the relatively large environmental footprint of the manufacturing process of electronic goods (Nissen et al. 2017).

Access Model.

In an Access model, the ownership of a consumer good remains in hands of a company offering the product as a rental service and the consumer returns the product after its paid use (Laubscher, Marinelli 2014). This alternative consumption model is the gateway to a sharing economy, where product use is more important than gaining possession rights over a product. Thereby the utilization factor of a product is maximized, as the resources inherent in an electronic product are being used more efficiently. Maintenance remains in the company´s hands, who will ensure that their products are easily maintained and can thus be accessed for a long period of time and prolonging an end of life.

Service Model.

In a Service model, the focus lies on the benefits of an electrical good rather than to the material attribute of the product. The service which is provided by an electronic good is fully delegated to a company who is providing a desired performance (Bakker et al. 2014). The consumer is decoupled from the actual product and is only interested in the service that is obtained from the product. From a material point of view, the electrical or electronic products remains in the hands of producers or service providers, who have access to maintaining and servicing the machines/devices. The service provider is also in full control of the material flows and the product status. This type of business model is likely to favour energy efficient devices as well as long lasting high-quality devices.

3 Circular Consumption Models.

3.1 Introduction and aims.

While there is an enormous body of knowledge on how to encourage customers to consume more, there remains far less understanding about what motivates them to make more ethical choices. In the context of PolyCE, measuring and understanding consumers' attitudes towards the circular economy, and more specifically on post-consumer recycled plastics, is an essential step in including consumers more effectively in the circular plastics value chain.

Underpinning most discussions about sustainable consumption are ideas about certain types of consumers, with "ethical," "green," "socially responsible," "alternative," or "frugal" being amongst the labels commonly used for those who adopt pro-sustainability behaviors. It is usually assumed such consumers act on their ethical beliefs, but that is not absolutely the case. Traditionally consumer motives have been used to define pro-sustainability behaviors, but ultimately how a consumer's behavior impacts the social and natural environment, not their motives, determines how sustainable their consumption is.

According to Parajuly, any environmental problems are rooted in human behavior, and behavioral changes are therefore needed to utilize the potential of technological innovations helping environmental sustainability (Steg and Vlek, 2009). The efficacy of intervention strategies to promote pro-environmental behavior relying on information campaigns is limited mainly because of the fact that environmental literacy does not necessarily translate into sustainable actions (Frisk and Larson, 2011). Human behavior is understood to be linked to both intrinsic as well as extrinsic attributes (Martin et al., 2017). In the context of sustainable consumption behavior, intrinsic attributes include knowledge, motivation, beliefs, habits, values, attitudes, intentions and other psychological variables whereas extrinsic attributes include social and cultural norms, monetary implications, and contextual variables such as infrastructure and institutional constraints (Jackson, 2005; Knussen and Yule, 2008; Young et al., 2009).

William Kardash (1976) first proposed that, except for a select few, everyone is a “potential ecologically concerned consumer,” and that, all other things being equal, every person would choose the most sustainable option. The challenge is that there are large inequalities in the quality, convenience, and price of sustainable or circular products, as well as consumer income levels, making it difficult for consumers in different parts of the world to all adhere to the same standard of sustainable consumption.

However, it is clear that seeking to identify those consumers who are most enthusiastic about sustainability, and developing “niche” products for them to buy (usually at premium prices), will not generate significant enough progress towards sustainability. Rather, it will require changes to mass markets and the broad spectrum of consumption behavior.

This chapter examines the opportunities to reduce overproduction of electronic waste and related negative environmental impacts through an active involvement of consumers in the Circular Economy and thus achieve dematerialisation of plastics currently used in electronic products. It features a thorough literature review, including experts’ interviews, and published literature on the topic of consumer behavior and engagement with the Circular Economy, backed up by data and conclusions based on an online consumer survey carried out by the United Nations University, in the framework of the PolyCE project. An analysis on the benefits and disadvantages of engaging with the circular and sharing economies for consumers is presented, alongside a review of the consumer adoption level and opportunities for businesses.

Ultimately, the chapter provides a set of recommendations targeting OEMs and small business enterprises that wish to leverage on the economic potential of the sharing economy, as well as recommendations targeting governments in supporting such initiatives). These recommendations are stemming from the pool of knowledge on consumption models gathered during the PolyCE project in Work Packages 1, 2 and 9. It is aiming to guide businesses and help them navigate through the complex and ever-changing fields of the circular and sharing economies and the related new consumption models that are becoming more and more attractive and mainstream. It is a depository of data and insight on how consumption models are becoming circular, service-oriented, community-based, and much more sustainable in a growing digital economy. Failure to adjust and leverage on the potential of this new and erupting trend will inevitably have a negative financial and reputational impact for businesses in the long-run.

3.2 Analysis of circular consumption models.

The below classification is presenting findings and conclusions stemming from the PolyCE consumer survey and the European Commission's Behavior Study on Consumers' Engagement with the Circular Economy and further backed up by literature review. The classification presents consumption models currently present or erupting. As the nature of the sharing economy is in constant motion triggered by innovation, consumption models are as well ever changing and new trends constantly appear.

Table 2: Analysis of circular consumption models. PolyCE elaboration

Consumption model	Main benefits	Disadvantages	Consumer Adoption Level
Buy used (C2C; B2C)	**Financial** (price is usually lower than the price of a new device); **Ethical** (lower environmental footprint)	Perception of low **quality** associated with second hand products[2] **Preference towards buying new** regardless of price. **Lack of awareness** of the existence of such model **Lack of sufficiently developed markets**	● According to the largest survey on consumers' behaviour carried out by the EC (2018): - Only 14-21% of respondents viewed purchasing a new product as better value for money – no matter the possible economic convenience. - Only 6% of consumers have bought second hand products over the last 5 years, in particular: vacuum cleaners (4,6%), dishwashers (5,4%), TVs (4,8%), mobile phones (8,3%). ● Influencing factors for buying second hand products include: 1) price 2) risk 3) brand 4) features 5)

[2] According to [EEB, 2017, p.22], "76% of consumers in developed countries would purchase more products that are environmentally and socially responsible if they performed as well as, or better than products they usually buy".

		Fear of data privacy violation Perception of lower **product safety**	location and buying channels (online or offline) (USBE, 2014). [3] ● Factors may change according to the type of products, eg. for e-products price and features are the most important. Moreover, socio-economic and cultural differences, also related to the geographical scope, may influence consumers' motivations.
Repair (C2C; B2C)	**Financial** (price is usually lower than the price of a new device); might even be free if the product is still under guarantee **Ethical** (lower environmental footprint) Depending on products: more incentives for large and expensive products	Perception of low **quality** **Preference towards buying new** regardless of price. Perception that the product is **obsolete** or **out of fashion** **Effort** (repair decisions are easily disrupted if arranging repair requires efforts)	● According to the EC survey on consumers' behaviour (2018): - 64% of consumer repair products. Specifically, 26% by service repair, 17% by manufacturer/retailer, 12% self-repair and 8% by friends or relatives. So, among repair experience, 67% were done by professional / manufacturer / retailer, which may indicate a potential market for businesses.[4] - In addition, consumers appeared to be rather satisfied with repair services, in terms of convenience (83,4%), speed of repair (80,8%),

[3] Umea school of business and economics – USBE. 2014. Factors that influence the decision when buying second-hand products, available at: http://umu.diva-portal.org/smash/get/diva2:839612/FULLTEXT01.pdf

[4] It is worth mentioning the difference across products:
- repair by professional repair service was higher for TV 58% (36,1 out of 62%), then dishwasher 53% (39,4% out of 74%), then mobile phone 41,5% (25,9 out of 62,4%) and finally vacuum cleaner 29% (17 out of 58,3)
- repair by manufacturer/retailer, was higher for TV 58,2% (36,1 out of 62%), then dishwasher 53,2% (39,4% out of 74%), then mobile phone 41,5% (25,9 out of 62,4%) and finally vacuum cleaner 29,2% (17 out of 58,3).

	Continuity: allow to keep all data, software downloaded and stored in the product.	**Lack** of repair **information** **Lack of spare parts at competitive price** Repair is **not always possible** (due to e.g. design not allowing non-destructive disassembly, part unavailable, instructions unavailable, incompatibility of software, embedded electronics requiring specialist diagnosis)	consumer friendliness (87,6%), and quality of the repair (87,5%). ● Similar results were obtained by the PolyCE consumers' survey: 68%of respondents declared to be willing to repair old products, rather than buying new. ● 118,000 tonnes of EEE is shipped each year for repair or remanufacturing (Digital Europe, 2014). If we estimate an average weight of 5kg per unit, that would amount to 23 million units shipped for repair each year in Europe. As many repair activities taking place throughout the world are informal, these data may give an idea of the extent of possible market opportunities in the 'repair' sector. ● Companies and manufacturers can play an important role. Among the actions that could foster the 'repair' sector we can list: i) making repairing information available; ii) making spare parts more available on the market; iii) design of reparable products
Buy remanufactured (B2C)	**Financial** (price is lower than the price of a new device) [5]	Perception of lower **quality** associated with remanufactured products	● According to the OECD (2018), the market penetration of remanufacturing EEE is only 0-1% in 2018.. Other sources (Vogtlander, 2018) say that the ratio of remanufacturing to manufacturing is only

[5] According to [ERN, 2020], "Remanufactured products (not limited to electronic products) are typically 60-80% of the cost of a new product due to the cost savings made from the recovery of the materials and energy content of the product"

	Ethical (lower environmental footprint) **Quality guaranteed by remanufacturer** **Potential enhancement or changes to the components** **Extra-services** (e.g. leasing, take-back, upgrading, supply-and-operate)	**Lack of awareness** of the existence of such model **Preference towards buying new** (have the latest available functional features, and the newest designs) Perception of lower **product safety**	1.9%. However, its potential is expressed by numbers and previsions: in 2015 remanufactured EEE in the EU represented a turnover of around 3.1 billion euro, which could attain an annual value of 6.5-19.4 billion euro by 2030 (ERN, 2015). ● Quality results to be the major factor affecting purchase decision of eg. a remanufactured bike. It indicates remanufacturers should focus on quality and attempt to improve the quality of products to gain more competitive advantage. ● Requirements for the responsible disposal of consumer electronics and ICT by the public and by businesses would increase the volume, and potentially the quality, of stock for remanufacturing (ERN, 2015). ● Other explored areas for potential improvement for companies operating in the remanufactured sector include (Lars, Oskar 2017): visibility, practicality, value perception, company's image, offered products, assortment, value for money/risk, transparency, customers' experience
Buy refurbished (B2C)	**Financial** (price is lower than the price of a new device);	Perception of lower **quality** associated with refurbished products *vs*. high risks perceived = misconception of refurbishment concept	● According to the EC survey on consumers' behaviour (2018): - Consumers' choice to purchase refurbished is mainly based on price consideration (good price-quality ratio, large price difference with new product)

	Ethical / Environmental (lower environmental footprint) **Quality guaranteed by refurbisher** **Higher performance** than second-hand products Absence of undesirable innovative features (innovation can suffer start-up problems or require new accessories etc.)	**Lack of awareness** of the existence of such model Lack of availability **Preference towards buying new** (have the latest available functional features, and the newest designs) Perception of lower **product safety**	● According to the OECD (2018), the market penetration of refurbished smartphones was 4-8% in 2018. ● According to a survey conducted in the Netherlands (TU DELFT, 2016)[6], one of the main reasons for not taking e.g. a refurbished phone is lack of awareness and misunderstanding of refurbished means. Also, there is a general negative trade-off between perceived risks and benefits. The assessment by consumers of main benefits/risks is usually related to personal, contextual and product-related factors. ● Research finds that consumers' willingness to pay (WTP) for refurbished products is low. Strategies for a higher WTP are needed in order to grow consumer markets for refurbished products. Eco-certification of refurbished products may be a key strategy (Harms and Linton, 2015) ● Several researches and consumer surveys carried out in the U.S. show a real potential of refurbished electronics (Rallo, 2018): the refurbished market for consumer electronics is estimated to be $10 billion; 75% of survey respondents say they are likely to buy

[6] TU Delft (2016), Paving the way towards circular consumption. Exploring consumer acceptance of refurbished mobile phones in the Dutch market, https://pure.tudelft.nl/portal/files/42664520/Paving_the_way_towards_circular_consumption.pdf

			refurbished electronics and 94% state they have bought refurbished in the last three years.[7] ● There are no guidelines and standards for refurbishment, which can lead to a general lack of recognition among authorities / consumers/ companies (Sharma & Sharma, 2014). • Starting point for companies: building a strong product basis, optimizing the original product design for multiple lifecycles. Then they should implement 3 steps: attract, convince, involve (TU DELF, 2016)
Lease / Rent / Pay-per-use (B2C)	**Financial** (cheaper if device needed for a limited period of time) Opportunity to **access new and diverse**	**Contractual engagement** can discourage some people **Lack of full ownership** of the device;	● According to the EC survey on consumers' behaviour (2018): only 1% of consumers have rented or leased products over the last 5 years, in particular: vacuum cleaners (0,8%), dishwashers (1,1%), TVs (1,1%), mobile phones (2,6%).

[7] - 84% of consumers who have purchased refurbished products are satisfied with product functionality and the price paid for the value received.
- 81% of the consumers surveyed are likely to recommend buying refurbished products to their family and friends.
- Desktop e-commerce alone is expected to grow by 12% annually
- 80% of consumers consider price important when choosing electronics and 96% say buying refurbished helps them save money. Additionally, 74% state that refurbished products allow them to meet their needs without paying for more than they need, and 45% say they allow them to try out a new product without larger financial commitment
- 95% of consumers state that warranty information is key to buying refurbished
- 57% percent of consumers say that a brand-name refurbished product is a key consideration in their purchase decision

ACCESS BASED CONSUMPTION	**products**, without the burden of ownership **Ethical** (lower environmental footprint) Possibility to **test the product;** makes possible access to more professional type-high performance appliances **Dematerialization:** access of consumers to latest technologies **Customized service** and **Accessibility** **Convenience** **Several schemes**: specialized shops or internet-based	**Lack of clarity on responsibility** in case of problems **Lack of awareness** of the existence of such model for EEE products **Lack of sufficiently developed markets**; **Fear lack of availability** when in need for the device. **Fear of data privacy violation** **Less trust in the providers** of services social concerns (for certain type of products, e.g. clothes)	● According to the PolyCE Survey: 6 out of 10 respondents already rented a tech product, including tools, household devices, but also cars[8]. Even though more than half (55%) of the respondents were not aware of such a service (rental), 84% of them were positive about the possibility of renting tech products instead of buying them, and mainly for large household appliances (81%), consumer electronics (70,5%) and smaller household appliances (48,9%). ● Instead of buying and owning things, consumers want access to goods and prefer to pay for the experience of temporarily accessing them. Ownership is no longer the ultimate expression of consumer desire (Chen 2009; Marx 2011).[9] ● The shift of consumers increasingly attracted to the idea of accessing, rather than owing goods, is important to businesses, as they pursue the growing market of consumers involved in alternative forms of circular consumptions (Lawson et al. 2016)

[8] The percentage difference between the EC survey and the PolyCE survey (1% vs. 60% of people having already rent or lease a product) is more probably due to the inclusion of "car renting" option within the PolyCE survey, which is one the most rented/leased product by consumer.

[9] Chen, Yu (2009), "Possession and Access: Consumer Desires and Value Perceptions Regarding Contemporary Art Collection and Exhibit Visits," Journal of Consumer Research, 35 (April), 925–40 ; Marx, Patricia (2011), "The Borrowers," New Yorker, January 31, 34–38.

	professional or peer-to-peer platforms		The following 6 dimensions should be considered as relevant: temporality; anonymity; market mediation; consumer involvement; type of accessed object; political consumerism (Bardhi, 2012).
Barter (B2C)	**Financial** (barter / exchanges between privates, no costs for intermediaries envisaged) Role of digital platforms **Upgrading** Opportunity to replace old with new model / upgrade while saving on the cost for a new device	**Lack of credibility of platforms operating online** (no consumer rights protection system available, privacy violations, financial schemes, and other consumer rights violations) - (applies to all digital platforms) **Fear of data privacy violation** Perception of lower **quality** associated with used products **Lack of awareness** of the existence of such model	● This is an emerging market in Europe which still has low visibility, which stems in the US. The potential lies in empowering consumers to substitute old for new products, while businesses benefit from monetising the value of resources within old but working devices at a lower price.

3.3 Opportunities for business.

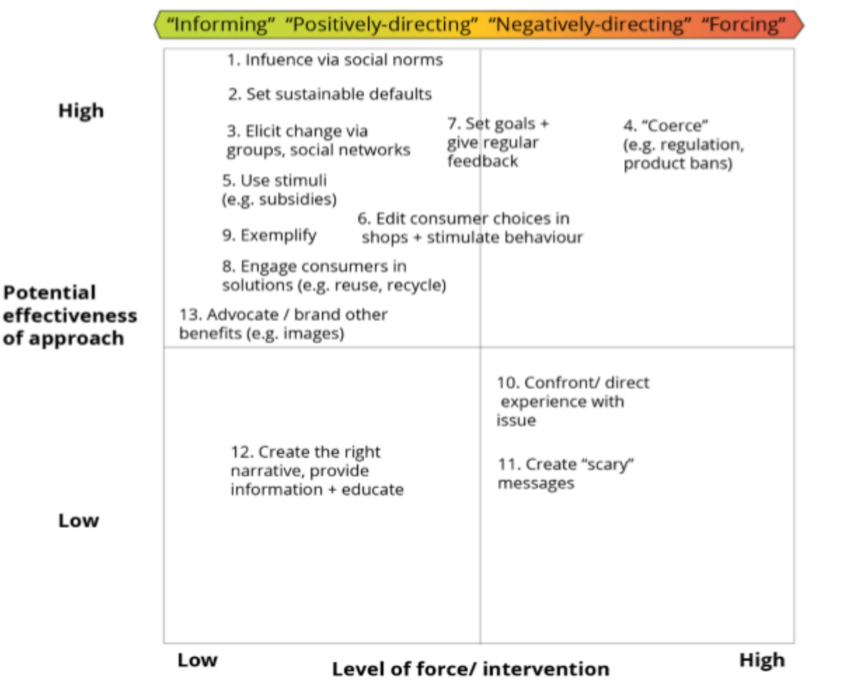
The successful application of circular economy principles in companies is closely related to the profitability of circular resource use, the companies' capacity to change their business models into sustainable and competitive ones, and the companies' capacity to respond to market demands, meaning to meet the customers' needs and expectations (Prieto-Sandoval et. al., 2018).

Consumer-serving businesses can shape consumer behavior in many ways, including influencing pro-sustainability behaviors. Businesses have long applied insights from behavioral sciences to make their marketing communications persuasive. Brand developers are well aware of the influence of image, emotions, peer pressure, price signals, and habits, and use these to great effect in influencing our purchasing choices (Blowfield, 2013).

Marketers are paying increased attention to harnessing communication and branding tactics to promote sustainable lifestyles and consumption patterns. Circular consumption models can be used as an environmental marketing tool for companies to differentiate their products and services. Proactive companies can thus demonstrate their commitment to environmental performance (Michaud and Llerena, 2006). Indeed, if people do not pay higher prices (maximum 2 to 4% for green products), green brands still have a competitive edge in attracting more buyers (Vogtlander, 2017, p.9).

There is a wide range of actions companies might take to encourage sustainable consumption. Below figure 1 includes some of the levers available to change consumer behaviour, categorised by their "level of force":

Figure 1: Potential options to influence consumer behaviour. (Adapted from Bocken & Allwood, 2012)



Although some options are primarily implemented by governments (i.e. regulations), there are several ways for companies to drive sustainable consumption (marketing, communications, and branding).

Product labelling is underpinned by voluntary standards and codes, which clearly identify products that meet specific environmental and social performance criteria. Off the back of increased consumer pressure on multinational corporations, social and eco-labels[10] have been introduced to encourage consumers to use their buying power to express their ethical preferences.

In the 2020 Circular Economy Action Plan (EC, 2020), the European Commission commits to enabling a circular economy that provides high quality, functional and safe products, which are efficient and affordable, last longer and are designed for reuse, repair, and high-quality recycling. A whole new range of sustainable services, product-as-service models and digital solutions will bring about a better quality of life, innovative jobs and upgraded knowledge and skills.

From a broader perspective, a number of studies have started to investigate the benefits and opportunities deriving from the increasing shift to a circular economic model in different sectors, including the electronic one. These encompass both opportunities for individuals and companies, as well as economic, environmental and system-wide benefits. Below, some of these elements are briefly described:

[10] Some of the most familiar include the EU Ecolabel, Germany's Blue Angel scheme, organic and Fairtrade produce, TCO, energy efficiency labels, among others.

Figure 2 Circular Economy, Benefits and opportunities deriving from the increasing shift to a circular economic model Ellen MacArthur Foundation 2019, UNU elaboration

ENVIRONMENTAL AND SYSTEM-WIDE BENEFITS

Carbon dioxide emissions: could be reduced by half by 2030

Primary material consumption: possibly reduced by 32% by 2030

Land productivity and soil health: Higher land productivity, less waste in the food chain, and the return of nutrients to the soil will enhance the value of land and soil as assets.

ECONOMIC BENEFITS

Economic growth: achieved through a combination of increased revenues from emerging circular activities and lower cost of production

Material cost saving: annual-net material cost savings opportunity in complex medium-lived products (mobile phones, washing machines, etc) is estimated up to USD 630 billion

Job creation potential: positive employment effects due to increased spending vs. lower prices; high-quality and labour-intensive recycling; higher skilled manufacturing jobs

Innovation: enormous creative opportunity in replacing linear products and systems

OPPORTUNITIES FOR COMPANIES

Profit opportunities: new profit streams encouraged, eg. costs for remanufacturing of mobile phones could be reduced by 50% per device

Reduced volatility and greater security of supply: using less virgin material + more recycled inputs may reduce risks related to threats to supply chain

New demand for business services: reintroduction of end-of-use products in the system, sales platforms facilitating longer use of products

Improved customer interaction and loyalty: new ways to creatively engage consumers

OPPORTUNITIES FOR INDIVIDUALS

Increased disposable income: average would increase by EUR 3k by 2030

Greater utility: customer choice increases as producers tailor products to meet their needs

Reduced obsolescence

Health: costs associated with pesticides use could be lowered by USD 550 billion globally + 290,000 lives/year could be saved by outdoor pollution by 2050

Looking more specifically at the collaborative economy, according to a 2016 European Commission Memo, "the collaborative economy is small but growing rapidly, gaining important market shares in some sectors. Gross revenue in the EU from collaborative platforms and providers was estimated to be EUR 28 billion in 2015. Revenues in the EU in five key sectors almost doubled compared with the previous year and are set to continue expanding robustly. Growth has been strong since 2013 and accelerated in 2015 as large platforms invested significantly in expanding their European operations. Going forward, some experts estimate that the collaborative economy could add EUR 160-572 billion to the EU economy. Therefore, there is a high potential for new businesses to capture these fast growing markets. Consumer interest is indeed strong, as confirmed by a public consultation and a Eurobarometer poll." (EC, 2016) Indeed, according to a 2018 Flash Eurobarometer survey entitled "The use of the collaborative economy," (DG COMM, 2018)[11] nearly a quarter of Europeans have used services offered via

[11] https://data.europa.eu/euodp/en/data/dataset/S2184_467_ENG

collaborative platforms. Among those who have used services offered via collaborative platforms, nearly nine in ten (88%) would recommend those services. § A majority of users mention convenient access to services (73%), availability of user ratings and reviews (60%), the fact that services are cheaper or free (59%), and the wider choice of services (56%) as main advantages of using collaborative platforms compared to traditional channels.

The issue of how electronics could actually fit within a circular economy model has been partly assessed by the Ellen MacArthur Foundation in 2017. According to their study, with the growing role of cloud computing, electronic products act more and more as a simple gateway to our data, applications and entertainments. In principle, this means that users are more open to letting go of their devices or using products that are not new, as long as they can access their data and benefit from its utility. In such a circular system, users can find new products matching their lifestyle in an easier and faster way. To achieve this vision, the EMF study underlines 4 ambitions required: "1) electronic devices are loved for longer, by one user or by many; 2) devices are gateway to the cloud; 3) customers get the service that's right for them; 4) products and components are cascaded" (EMF, 2018).".[12]

We will now delve more into details in some main CE consumption models, to highlight existing opportunities for businesses to further invest on/develop these models, considering the current attitude of consumers, and thus the possibility to leverage and create incentives to increase this share of the market.

3.3.1 Buy used.

Similarly to other circular consumption models, there is a general lack of research and knowledge in the field of second-hand products.

According to Williams and Paddock (2003)[13], who conducted interviews with 120 consumers in Leicester (UK), there are financial but also rational explanations for participating in informal and formal second-hand channels. People may look for distinction, by buying products that are currently not available on the market or they fight against the consumption system. Ecological motivations are also to be mentioned.

Based on another survey conducted in Germany[14] in 2015, with 231 participants, main motivations for buying used products include: fair price and the gratification role of price (economic motivation) ; distance from system, ethics and ecology (critical motivation) ; treasure hunting, originality, social contact, nostalgic pleasure (hedonic and recreational motivation).

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[12] https://www.ellenmacarthurfoundation.org/publications/circular-consumer-electronics-an-initial-exploration#purchase-options

[13] Williams, Colin C., and Christopher Paddock. 2003. 'The meaning of alternative consumption practices.' Cities 20 (5): 311–319, available at: https://www.researchgate.net/publication/232390123_The_Meaning_of_Alternative_Consumption_Practices

[14] Steffen A. 2017. Second-hand consumption as a lifestyle choice, available at: https://www.researchgate.net/publication/314370970_Second-Hand_Consumption_as_a_Lifestyle_Choice

Motivations are different if compared to studies from UK (Williams and Paddock 2003; Waight 2013[15]) or France (Guiot and Roux 2010): in UK many consumers have to buy used products in order not to be excluded from society, or to survive because of financial hardship. While, according to Williams and Paddock (2003), economic motivation is not the first driver for German consumers.

This may suggest the need for companies, on one side, to consider the geographical scope when developing marketing strategies and if decide to invest in second-hand products. In fact, socio-economic and cultural differences may influence consumers' motivations and choices. As an example, an understanding of the motivational drivers helps eg. fair organisers, second-hand shop managers and individuals who sell in informal channels.

Focusing on electrical and electronic equipment (EEE), while there may be some pull factors that facilitate the trade of second-hand EEE, such as the need to satisfy the growing demand for home appliances, especially in certain regions of the world, some factors can make this consumption model overall more challenging for these type of products.
The Institute for Global Environmental Strategies (IGES), backed in 2010, summarized 4 types of second-hand EEE related issues[16]: 1) the unusable/non-repairable end of life EEE, which can be disguised and traded as second hand, thus creating possible threat to safety and fuelling illicit trade/expert ; 2) the second hand EEE which are almost unusable or end-of-life, which can become waste very soon and have a short remaining life; 3) real usable or reparable second-hand EEE, which can be sold and used in imported country or, in case, repaired (*see next paragraph*); 4) usable or reparable but energy insufficient second-hand EEE, that can be used directly or after being repaired, but are usually less energy efficient than brand new or refurbished/remanufactured EEE.

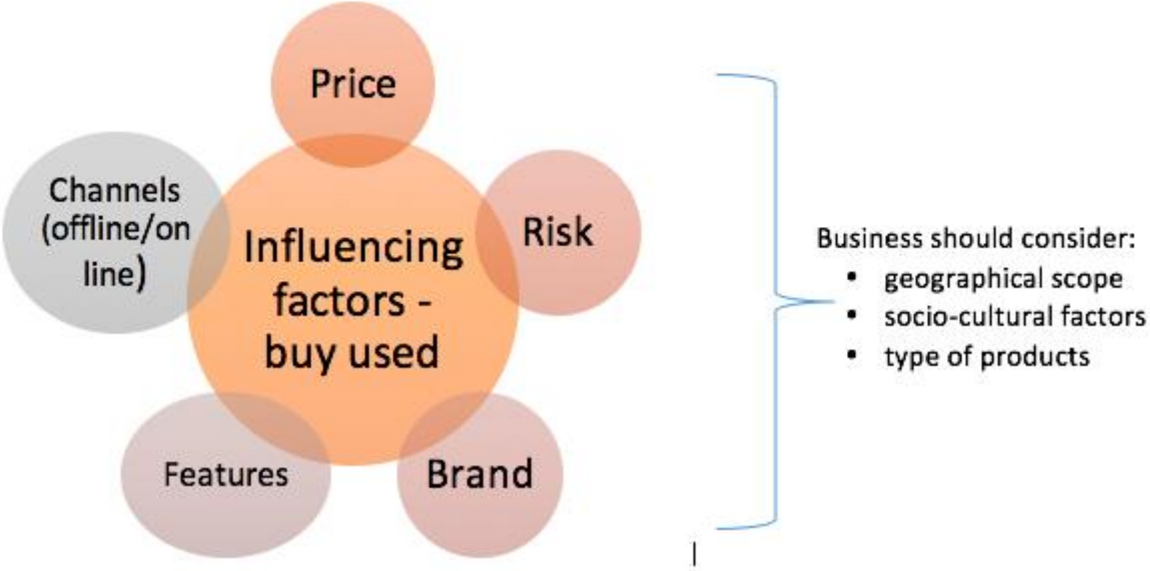
Overall, businesses should take into account the different factors that influence consumers in buying second hand products, including but not limited to: i) price ; ii) risk ; iii) brand ; iv) features; v) location and buying channels (offline and online). These factors may change according to the type of products: for EEE products features are the most important ones, as they have to work properly, followed by price.[17]

[15] Waight, Emma. 2013. 'Eco babies: Reducing a parent's ecological footprint with second-hand consumer goods.' International Journal of Green
Economics 7 (2): 197–211

[16] IGES. 2010. Trade of Secondhand Electrical and Electronic Equipment (SH-EEE) in Asia. https://www.iges.or.jp/en/publication_documents/pub/presentation/en/2103/aoki_sh_isieap.pdf, page 7

[17] Umea school of business and economics – USBE. 2014. Factors that influence the decision when buying second-hand products, available at: http://umu.diva-portal.org/smash/get/diva2:839612/FULLTEXT01.pdf

Figure 3: Business considerations for influencing consumer choices, USBE 2014, UNU elaboration



3.3.2 Repair.

Products' repairing involves both the formal and the informal sector. Focusing on electrical and electronic equipment, 118,000 tonnes of EEE is shipped each year for repair or remanufacturing (Digital Europe, 2014). If we estimate an average weight of 5kg per unit, that would amount to 23 million units shipped for repair each year in Europe.

However, many repair activities taking place throughout the world are informal. The experience of Repair Cafè or Restart project based in London represent an interesting example from the informal sector.[18] iFixit is a wiki-based platform that brings together a worldwide repair community and teaches people how to repair various products. Anyone can create a repair manual for a device, and anyone can also edit the existing set of manuals to improve them. The website empowers individuals to share their technical knowledge with the rest of the world. If the amount of activity on the website is any sort of indication, the volume of repair activities being performed worldwide is impressive. The website currently hosts over 20 000 repair guides and receives about 115 million visits annually.

These data already provide an idea of the extent of possible market opportunities in the 'repair' sectors, especially for EEE.

The Ellen MacArthur Foundation elaborates specific recommendations on how to empower the so-called 'fixer movement' (see Figure 4). These include:

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[18] https://www.ellenmacarthurfoundation.org/assets/downloads/ce100/Empowering-Repair-Co-Project.pdf

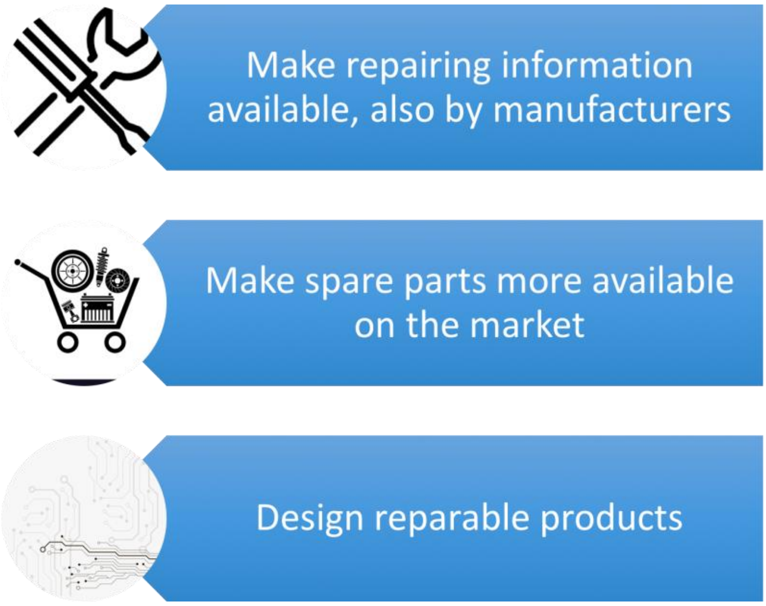
- Making repair information more available. Also by manufacturers, who should collaborate with existing platforms.

- Making spare parts and accessories more available.

- Designing repairable products.

Companies and manufacturers can play an important role, if they intercept the actual needs and habits of consumers for this specific consumption model and manage to cooperate even with consumers' based platforms for repairing.

Figure 4: Recommendations on how to empower the so-called 'fixer movement' 'Ellen McArthur Foundation, UNU elaboration



3.3.3 Buy remanufactured.

Buying remanufactured still remains a limited consumption model for consumers, including in the area of EEE: in Europe, the ratio of remanufacturing to manufacturing is only 1.9%.[19] However, its potential is expressed by numbers and previsions: in 2015, remanufactured EEE in the EU represented a turnover of around 3.1 billion euro, which could attain an annual value of between 6,5 and 19,4 billion euro by 2030.[20]

Based on a study by Vafadarnikjoo et al. (2018), who explored the major motivational factors for buying a remanufactured product (e.g. a bike) based on consumers' and experts' opinions collected through the Delphi method, quality results to be the major factor affecting purchase decision of remanufactured products, which indicates remanufacturers should focus on quality and attempt to improve the quality of products to gain more competitive advantage.

[19] Vogtlander, 2018, p.3

[20] ERN, 2015, p.50

Requirements for the responsible disposal of consumer electronics and ICT by the public and by businesses would increase the volume, and potentially the quality, of stock for remanufacturing (ERN, 2015, p.84). Other six factors that should be stressed by remanufacturer's marketing strategies are prioritised as: 1) warranty, 2) price, 3) information provision, 4) remanufacturer's reputation, 5) value-added services and 6) retailer's reputation respectively.[21]

3.3.4 Buy refurbished.

In the shipment towards a circular economy, refurbishment helps in regaining value from used products and in reducing the amount of waste.

Even though, refurbishment is different from remanufacturing, in the academic literature they are often used interchangeably. A number of academic studies, in fact, explore different aspects of these consumption models, providing remanufacturing guidelines to companies (Hatcher et al. 2011, Subramoniam et al. 2013) and elaborating functional design tools and methods to enhance products' re-manufacturability (Allwood et al. 2011). However, in order to increase the amount of refurbished products in the market, there is a need of insights on how to develop refurbished products that will have strong appeal to consumers (Jiménez-Parra et al, 2014; Souza, 2013).

While the consumer perspective on refurbished goods is still quite unexplored, an interesting study conducted in The Netherlands by the Delft University of Technology (2016)[22] provides a comprehensive understanding of the main factors influencing the consumer acceptance of refurbished products, in particular mobile phones, and can help companies to grasp those factors and refine/modify their actions accordingly.

The research uncovered that consumers usually do not consider this type of consumption model because of a lack of awareness and a misunderstanding of what refurbishment is and entails. Refurbished products are also often rejected because of the perceived risks, considered higher than the actual benefits. Several factors related to the context or the product itself may influence the customers' perception of this trade off risks vs benefits.
How can designers / marketers positively steer consumer perception of refurbished products?[23]
The starting point is building a strong product basis --> optimizing the original product design for multiple lifecycles, by i) including design for circularity in the design objectives, and ii) integrating product design in the refurbishment process. The combination of these two perspectives allows developing an efficient refurbishment process, enabling maintenance, recovery and modification of products. When the product basis is strong, the approach proposed by TU DELFT (2016) includes three main steps: attract, convince and involve (see figure 5 below).

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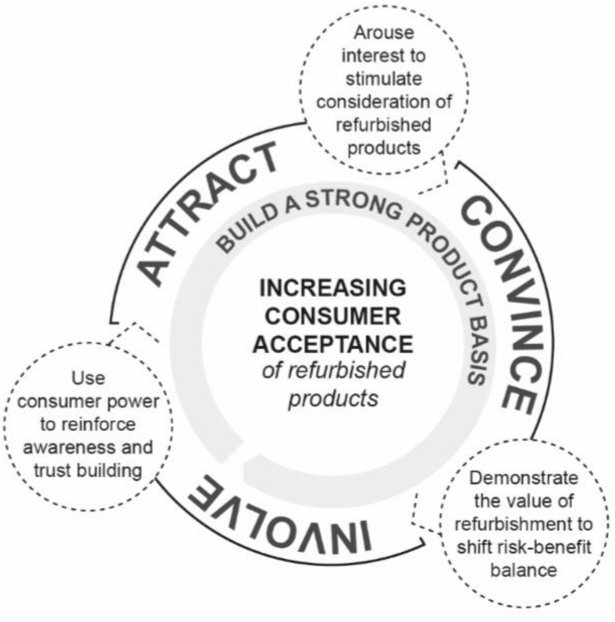
[21] Vafadarnikjoo et al. 2018. https://www.sciencedirect.com/science/article/pii/S095965261831686X

[22] Van Weelden E., Mugge R., Bakker C. 2016. Paving the way towards circula consumption: exploring consumer acceptance of refurbished mobile phones in the Dutch market. https://pure.tudelft.nl/portal/files/42664520/Paving_the_way_towards_circular_consumption.pdf

[23] See, as main reference for this paragraph Van Weelden et al. 2016, chapter 5 *Towards increasing consumer acceptance: practical guidelines.*

Figure 5: Increasing consumer acceptance of refurbished products in three steps. Van Weelden et al. 2016



This approach, which looks at the consumer acceptance of a circular consumption model from a decision-making perspective, can be possibly applied to other consumption models. In fact, a product - being refurbished, remanufactured, second-hand etc. - can be either accepted or rejected at different steps in the product acquisition process, where a variety of obstacles can arise, mainly related to a lack of familiarity with CE models or even weak image associated, for instance, with refurbished products.

"[O]nly when consumers accept and purchase refurbished products as substitutes for new products (and not supplement), refurbishment can contribute to a sustainable society".[24]

ACCESS-BASED CONSUMPTION: LEASING, RENTING, PAY-PER-USE

While access based consumption, which includes circular models such as leasing or renting, has been a significant trend in the last decade in the consumer markets, nowadays the state of the art of research in this field still remains scarce.[25]

From a theoretical point of view, access-based consumption has been conceptualized as distinguished from other modes of consumption, like sharing[26] and ownership.[27]

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[24] Ibid, p.28

[25] Main studies in this field include: Bardhi & Eckhardt, 2012; Belk, 2014; Lamberton & Rose, 2012; Moeller & Wittkowski, 2010; Ozanne & Ballantine, 2010; Schaefers, Lawson, & Kukar-Kinney, 2015.

[26] Conceptualization of 'sharing' by Belk (2010), as 'sharing-out': theoretical framework that explains access-based consumption under more social, not-for-profit contexts in which consumers access one another's property (peer-to-peer sharing) or consume from a commons. See Belk (2010), "Sharing," Journal of Consumer Research, 36 (February), 715–34

[27] Bardhi F., Eckhardt G.M. 2012. Access-Based Consumption: The Case of Car Sharing, *Journal of Consumer Research*, Volume 39, Issue 4, 1 December 2012, Pages 881–898. https://academic.oup.com/jcr/article/39/4/881/1798309#96625795

Access-based consumption can be an alternative source of profit for companies in different sectors, including car/bike sharing services; luxury product rentals; even intangible goods (eg. skills, available space such as offices or apartments).
According to Zhuo (2015)[28], access-based consumption revenues are rising from 15 USD billion globally in 2014, to over 300 USD billion by 2025. Understanding consumers' motivations, and leveraging on them, can definitely help companies in expanding their role in this market share and reach a wider number of customers.

In general, businesses will need to leverage on potential risks which may impede consumers' access-based behaviors, including financial risk, performance risk, psychological or social risk.

The following six dimensions should be considered, as relevant in the overall field of access-based consumption, as they could guide future research and developments: temporality, anonymity, market mediation, consumer involvement, type of accessed object, and political consumerism.[29] For instance, the type of accessed object may shape the consumer-object relationship. Given that many core consumer behavior theories take ownership as an assumption, investigating alternative modes allows companies to question established relationships regarding consumer-object, consumer-consumer, and community relations.

3.4 Conclusions and Recommendations.

Changing production and consumption practices requires a radical shift in current consumer mind-set and related consumer behavior. Both industry and consumers have to play their part in promoting a more sustainable way of producing and consuming products and services. Moving away from established production, purchasing and ownership models to embracing circular economy and systems thinking requires businesses and consumers to work together. The role of government in supporting such initiatives through various political instruments cannot be underestimated.

This initial change from linear towards circular consumption may be unfamiliar for consumers, and uncomfortable for industry at first but the end result is an economy that thrives in the long term, while enabling the environment and society to do the same. The key is integration and ensuring that changes are made across every part of the value chain, because change on this scale requires cooperation from every player involved in the process.

In the context of the PolyCE project, WEEE plastics dematerialisation depends on the collective action of all actors in the product value chain. The preferences, attitudes and actions of consumers are key to drive a bottom up consumer demand and ultimately a market-shifting trend that will inevitably catch the attention of business. However, research and experience gathered throughout the project's duration are teaching us that counting solely on a consumer demand for sustainable products is a lengthy and ineffective strategy when a substantial, swift and radical shift is needed

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[28] Zhuo, T. (2015). Airbnb and uber are just the beginning. What's next for the sharing economy. http://www.entrepreneur.com/article/244192

[29] Bardhi F. Eckhardt G. (2012). Access-based consumption: the case of car sharing. Journal of Consumer Research, Vol. 39, Issue 4, 881-898. https://academic.oup.com/jcr/article/39/4/881/1798309#96625795

in the short run, such as addressing the rising threats of plastic pollution and electronic waste. At the same time, actions of consumers are slowly but surely leaving a mark and will eventually “move the needle” only if a large body of people make sustainable choices and act on their beliefs. Educating, information sharing, nudging and providing availability of options to consumers are among the key prerequisites for a more effective adoption of the CE on the side of consumers.

The following are PolyCE’s recommendations to businesses and governments that serve to aid and guide the process of adopting consumer-relevant circular economy considerations more effectively by all actors in the economic value chain.

Table 3: PolyCE's recommendations to businesses and governments

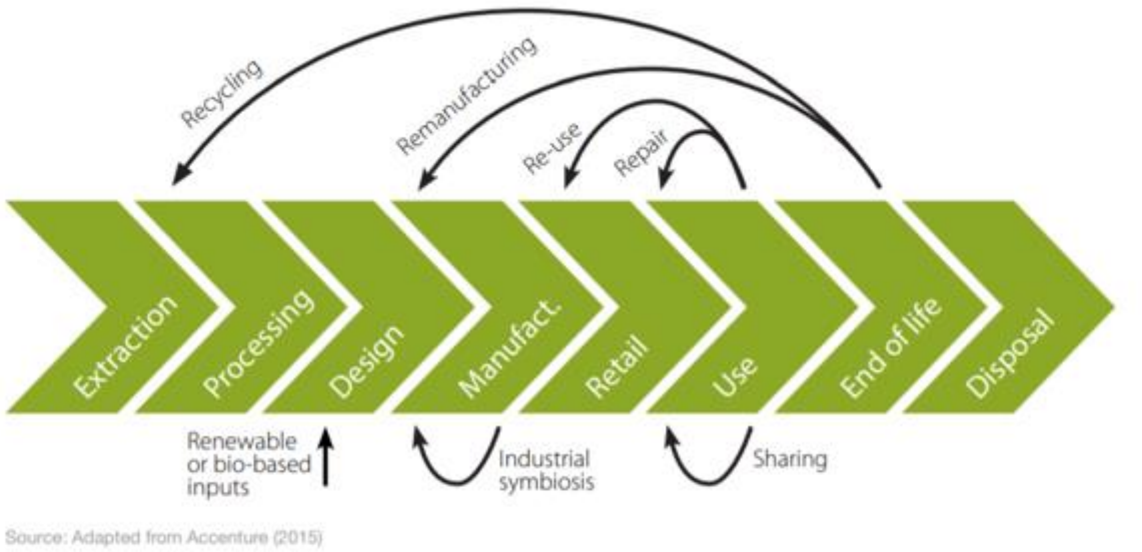
Target audience	Recommendations
Business sector	- **Improve visibility of and information about circular consumption models and products.** *Consumers need to be given advice on how they can benefit from circular consumption models: emphasized technical quality (composition, performance, durability, reparability, upgradability, remanufactured/refurbished characteristic, safety and security, privacy data ensured, etc.), service (take-back option, guarantee, maintenance, etc.) and environmental impact information (energy saving, weight or percentage of saved components, etc.) should always be available and clear to help and guide consumer choice.* - **Improve existing educational and information programs** *to provide individuals with a better understanding of the environmental footprint of their consumption choices. The use of behavioural insights and nudges, such as labelling requirements, may be a promising way forward (OECD, 2018).* - **Facilitate consumer access to circular products and related services.** *Besides being informed about the benefits from circular business models and products,consumers should also be provided with an equal access to circular products and related services (including for example repair shop, leasing/renting platform, used/remanufactured/refurbished markets, etc.)* - **Improve credibility and reliability of online circular business services:** *Consumers' data privacy must be guaranteed. Consumers should receive trustworthy and relevant information on products at the point of sale, including on their lifespan and on the availability of repair services, spare parts and repair manuals (European Commission, 2020, Circular Economy Action Plan For a cleaner and more competitive Europe).* - **Provide flexible business terms for consumers** that offer trial options, short or no contractual relationships, opportunity to receive access to repair or exchange services, etc.

	- **Promote upgradeability and long-term compatibility of software.**
Government sector	- **Enable green public procurement criteria** *to financially incentive companies to adopt and implement sustainable design strategies and components into their products and services.* - **Make product price-attractive:** p*rice is one of the key elements driving the consumer decision to opt for a new vs. for a circular option, circular options thus need to be less expensive than buying new. This can be done through various means, e.g. making deals with retailers, pass incentivizing regulation (e.g. lower VAT for circular options).* - **Create a community of peers sharing values and priorities** *to help consumers to save time and share tips for easing the transition period from linear to circular consumption habits. This can be facilitated by online platforms (EEB, 2017, p.23-24).* - **Distribute guidelines for designers / marketers to positively steer consumer perception of refurbished products** *(TU DELFT, 2016): Starting point: building a strong product basis □ optimizing the original product design for multiple lifecycles, by i) including design for circularity in the design objectives, and ii) integrating product design in the refurbishment process.* - **Include and update circular economy criteria into existing legislatio*n***, *i.e. Product and Organisation Environmental Footprint methods. The Commission will test the integration of these methods in the EU Ecolabel and include more systematically durability, recyclability and recycled content in the EU Ecolabel criteria (European Commission, 2020, Circular Economy Action Plan For a cleaner and more competitive Europe).*

4 Circular Business Models.

4.1 Introduction.

Figure 6: Circular business models operate in different parts of the value chain. Source OECD (2018)



It is clear that CE represents a radical shift in our society; both in consumption patterns and how business is conducted. It is seen as an important shift, views on how this shift will be monitored and the pace that it can happen vary, but it is generally agreed that the pace will be determined by both the legislative framework and the commercial attitude to change. It is currently simpler for business to be conducted in a linear way, and the adoption of CEBMs will need to run in parallel with linear business practice before a paradigm shift is achieved (Colley-Jones et al. 2019). Definitions of the different CEBMs where outlined in Chapter 2.

Many of the organisations that were interviewed to develop the case studies in this chapter, have a long history of embedded sustainability and resource efficiency goals. Increasingly though, these organisations are seeing added value in developing closed loop systems and other CEBMs both from an economic and environmental perspective

4.2 EEE producers - current circular business model best practice case studies.

4.2.1 Case study 1 Philips - systemic approach.

Figure 7: SENSEO® Viva Café Eco HD6562 and sustainable packaging (reproduced courtesy of Philips, 2020)

Philips are committed to the United Nations Sustainable Development Goals 3, 12 and 13 (UN, 2015) and aim to achieve sustainability through innovation with an ambitious goal of improving the lives of 3 billion people by the year 2030 (Philips n,d.a). They have focussed on the Circular Economy as part of their "Healthy people, Sustainable Planet" programme ensuring they embrace sustainable consumption (SDG12) and Climate Action (SDG13). One of Philip's Key Performance indicators is that 15% of their revenues should come from CE business models by 2020 (Philips n,d.a).

The Circular Economy is central to their vision and through company policies have recognised the need for change with regard to overconsumption of resources, growing demands from an expanding population and waste, pollution and climate issues. Through innovative business modules (performance and access-based models) and by maximising the lifetime of products and solutions (refurbishment, parts recovery, onsite and remote upgrades and recycled materials) they are actively transitioning to a circular economy (Philips, n.d.a).

Since 2010 Philips has been introducing the use of recycled plastics into its product portfolio and where a key signatory after success in other areas (garment and floor care) they looked to develop new products including the SENSEO® coffee machine product range (Figure 7). With regard to SENSEO® Original they determined that opportunities for the use of recycled plastics related to the manufacture of the base plate (due to non-direct contact with food). Challenges were faced in terms of a negative smell experience (the aroma of coffee being a key part of the coffee making experience for the consumer), heat resistance requirements and aesthetics, however, challenges were overcome and SENSEO® Original was produced using ~160 grams of recycled plastics which, equated to just under 16% of the total plastic weight (Philips, n.d.$_{b}$).

The design and development of SENSEO® Viva Café Eco HD6562 aimed to further increase the use of recycled plastics within a new product which would allow Philips to reflect consumer pressure for more sustainably designed products whilst maintaining excellent tasting coffee. Circular Economy is all about collaboration and Philips' partner in the Senseo system are Jacobs Douwe Egberts who produce an industrially compostable coffee pod (Figure 8) and sourcing their coffee sustainably, using 100% UTZ certified coffee in all of the SENSEO® black coffee pods varieties. This system approach provides customers in their words with:

"Great coffee taste with care for the environment"

Figure 8: Industrially compostable coffee pod produced in collaboration with Jacobs Douwe Egberts (reproduced courtesy of Philips, 2020)

The SENSEO® Viva Café HD6562 contains in excess of 75% (of total plastic weight) recycled plastics, 28% less energy consumption (than the predecessor HD6563) and a reduced CO_2 footprint (again in comparison to predecessor HD6563). More importantly Philips in partnership with Jacobs Douwe Egbert have developed a competitively low global warming potential (CO_2) coffee system.

Global consumer trends indicate that purchasing habits are increasingly reflecting consumer awareness of sustainability and environmental issues. Customer expectations and competition in the marketplace is evolving and there is growing pressure to deliver quality products, competitive pricing and focus on environmental social responsibility (EC, 2008; Kuchinka *et al*., 2018). In addition, it is vital for a company like Philips to maintain customer loyalty as other competitors, such as Nespresso, are also in the process of promoting their sustainability programmes (Nespresso, n.d.). However, research indicates that purchasers will be loyal to a company after the organisation has embraced sustainability and environmental awareness (Kuchinka *et al*., 2018; Grubor *et al*., 2017).

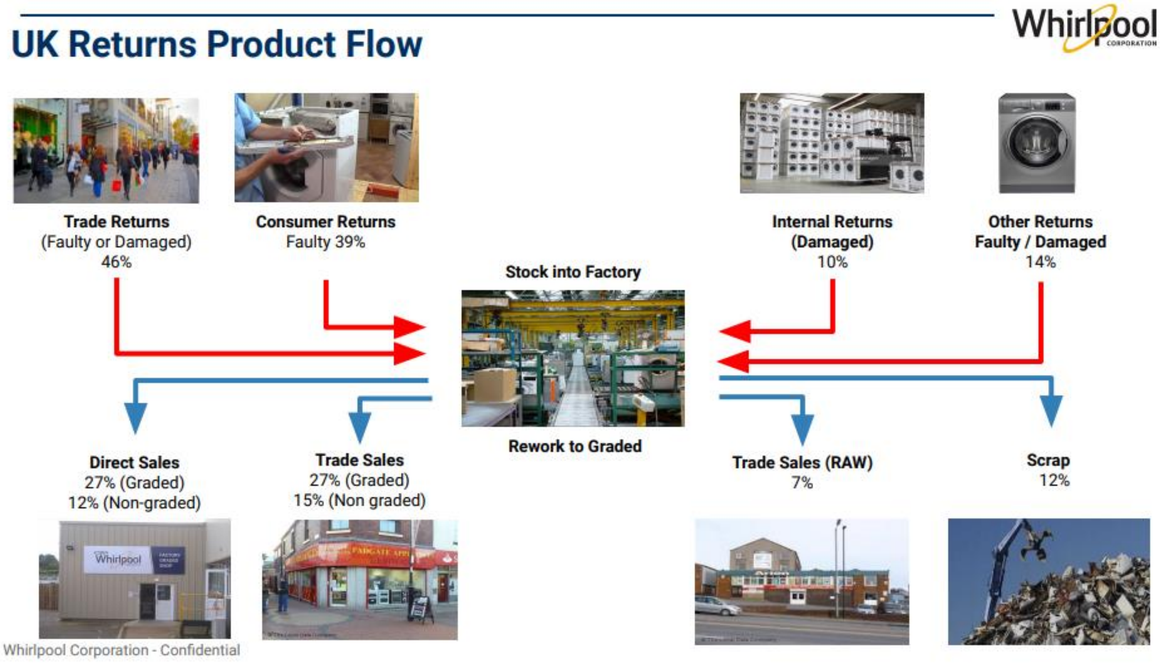
4.2.2 Case study 2 Whirlpool Corp – UK returns product flow.

Whirlpool Corp Sustainability focus on five key programs: Carbon, Plant Efficiency, Circular Economy, Design for Environment, and Sustainable Home Innovations. In terms of Circular economy Whirlpool Corp are aiming to deliver solutions that allow Whirlpool Corporation to implement more closed-loop models, drive recycled content, and overall circularity across the value chain at a global level. Products are looked at from a complete life-cycle perspective including design, production, use in home and collection and recycling. Whirlpool Corporation along with retail partners participates in over 45 appliance take-back programmes in different states, provinces and countries, where the majority of their products are recycled or reused at the end of life. This case study shows further details of their UK returns product flow.

In the UK Whirlpool products are returned via a number of routes as can be seen in figure 9.

- Trade returns
- Consumer Returns
- Internal returns
- Other

Figure 9: UK Whirlpool Returns Product Flow (reproduced courtesy of Whirlpool)



On arrival at Whirlpool's own facility in Peterborough, Cambridgeshire, returns are fully refurbished back to factory standard (Whirlpool n.d). Depending on the condition of the product they are graded into two grades:

1. *R grade* :This is the highest standard of refurbished products which have been reworked in Whirlpools on site facility and come with a 1 year manufacturer warranty as standard.

Most of these appliances received minor damage during the original manufacturing or logistics process and although minor blemishes may still exist, these are generally limited to the sides and rear of the appliances.

2. *M Grade:* These refurbished products have generally been returned as either damaged or faulty from the retailer, and once reworked in Whirlpools on site facility come with a 1 year manufacturer warranty as standard.

   The products will have some cosmetic damage, which could be on the front, sides or rear of the appliance.

All appliances are fully functionally, safety tested and are sold complete with a full 1-year manufacturer guarantee covering parts and labour. A 10 years parts warranty is also available provided that the appliance has been successfully registered - this applies to large appliances only. For Whirlpool branded appliances a 2-year manufacturer guarantee (parts & labour), plus a 10-year parts warranty is also available upon appliance registration.

4.2.3 Case study 3 DELL –closed loop supply chain & refurbishment.

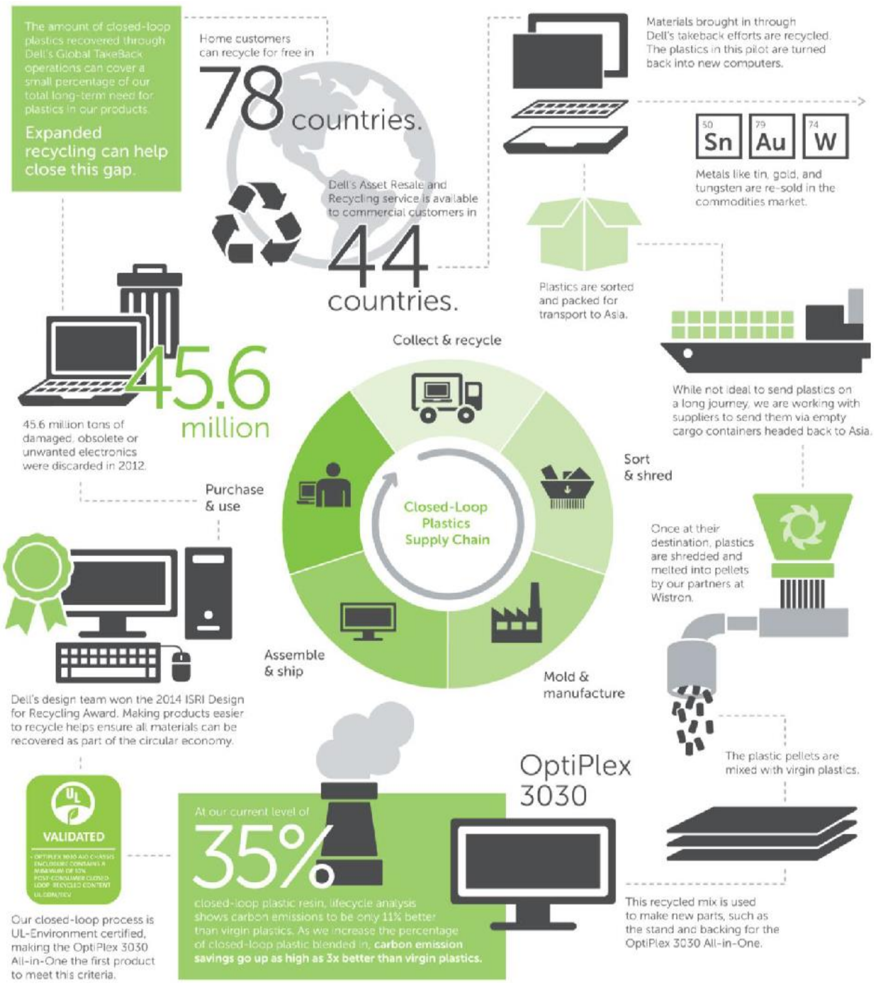
Dell has been using recycled content since 2008 and in 2012 Dell set a series of goals called the 2020 Legacy of Good goals, one of which is to use 100 million lbs (double its original goal of 50 million lbs which it achieved in 2017), of sustainable materials in recycled content plastics and other sustainable materials by 2020. Dell see an added value in developing a closed loop supply chain, in order to, not only reuse material that is End of Life, but to use their own material and material from their industry. There are added environmental benefits of using a closed loop source rather than just a recycled source. which they measure as their impact on Natural Capital, this describes the non-market value of the environmental resources that businesses depend on to grow revenue. Dell commissioned Trucost, (2015), to assess the net environmental benefit of closed-loop recycled plastic in terms of lower pollution, reduced greenhouse gas emissions, and improved human health compared to using traditional plastic. This involved quantifying positive and negative environmental impacts and putting a monetary value on the result.

Dell Reconnect programme is run in partnership with Goodwill. The Goodwill enterprise is a network of 157 community-based, autonomous organizations in the United States and Canada with a presence in 12 other countries. Dell collect electronics from 11 surrounding states around Texas, they are dropped off at over 2200 Goodwill locations and they range in size from just a small shop in a centre strip mall to a larger warehouse. The products that can’t be reused or refurbished are consolidated into those hubs and then from there they are all shipped into one electronics recycler, Wistron in Texas who recover the plastics which are then used in new computers thus “closing the loop”. The first closed loop product launched in 2014 containing 10% of recycled plastic and validated by ULe was the All in One computer Optilex 3030 as seen in figure 10.

Figure 10: OptiPlex 3030, the first product to contain 10% Closed- loop post-consumer recycled plastic a process validated by ULe (Trucost 2015)

Systems in working condition are refurbished by Goodwill, they have a programme set up to resale working equipment on the floor, if it's not working they have an educational programme set up, training employees to do basic repairs and basic refurbishment, and then from there the system gets resold on the shop floor. In addition, this program allows Goodwill customers to purchase modern technology at an affordable cost.

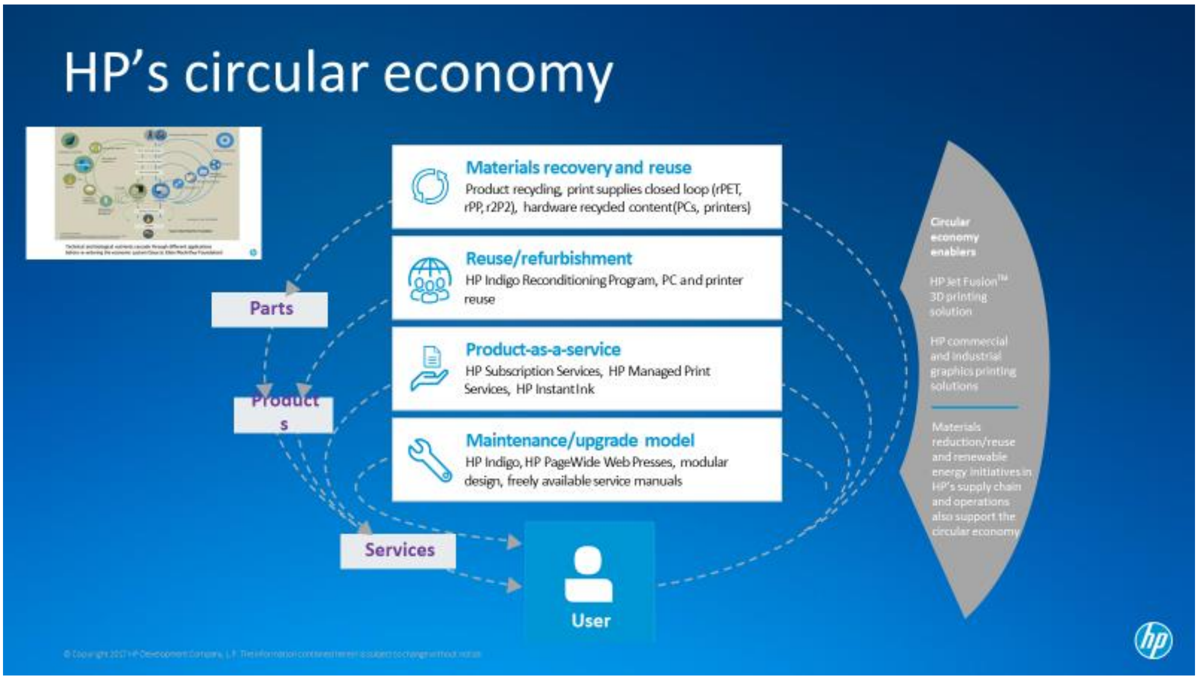
Figure 11: Dell's Closed-loop Recycling Process (Kyle, 2014)



4.2.4 Case study 4 HP business to consumer service model example.

Through its Pillar 2 objective (HP 2018), HP is looking at disruptive business models by reinventing the way its products are designed, manufactured, used and recovered as it shifts its business model and operations towards a material- and energy-efficient circular economy. At HP, a key concept in the circular economy is a materials cycle—where plastics, metals and other durable materials are continuously being used and reused for high-grade applications, without being “down-cycled” into lower-grade uses that eventually become waste (Strandberg 2017). HP sees a business opportunity in designing products and services that meet and enable circular economy applications for its customers as shown in figure 12.

Figure 12: HP Circular Economy (reproduced courtesy of HP 2019)



Instant Ink is an innovative example of a business to consumer product as a service model, figure 13 shows a visual representation of this.. Print services for business to business are well established, however business to consumer service models are a more difficult model to implement. HP’s ink subscription service, HP Instant Ink seeks to address this gap. Instant Ink has more than 1 million subscribers in six countries (Strandberg 2017). The service ensures customers never run out of ink when they need it, and that they can recycle used cartridges more efficiently (returned cartridges are fed into HP’s closed loop recycling program). HP use plastic from recycled Original HP cartridges (plus recycled bottles and hangers for ink cartridges) to create new Original HP cartridges. More than 80% of HP ink cartridges and 100% of HP LaserJet toner cartridges are now manufactured with recycled content (HP 2018). Through the service, an internet-connected printer notifies HP when it is running low on ink, and a replacement cartridge is automatically delivered. Compared with conventional business models printers using this service generate up to 67 percent less materials consumption per printed page (Strandberg 2017).

Figure 13: HP Instant Ink system (reproduced courtesy of HP 2019)

4.3 Circular plastics in EEE.

EEE contains a complex mix of valuable metals, plastics and critical raw materials. Circular economy business models (CEBMS) offer the opportunity to manage these valuable materials more effectively. Adoption of CEBMs has the potential to enhance resource management and material flows within global supply chains. The application of circular economy to the Electrical and Electronics Equipment (EEE) sector requires a system thinking approach, one which gives an understanding of the whole value chain and lifecycles of EEE (Meadows 2008) including design and end of life.

According to Plastics Europe, (Plastics Europe 2019) 61.8 million tonnes of plastic were produced in Europe in 2018, accounting for 17.2% of total plastics production globally. Europe is the third largest producer of plastics in the world; Germany, Italy, France, UK, Spain and Poland are the six highest producers of plastic products in Europe. Of the 51.2 million tonnes used by plastics converters in Europe, 6.2% of these were used in the electrical and electronic equipment (EEE) sector.

The European Commission’s Circular Economy Action Plan (EU 2015) highlights that waste electrical and electronic equipment (WEEE) is one of the fastest growing waste streams; currently increasing by 3–7% per year, WEEE is expected to grow in Europe to more than 12 million tonnes by 2020. The total amount of WEEE collected in 2014 was 3.9 million tonnes, and this has increased to 4.3 million tonnes (Eurostat 2018).

The total amount of WEEE derived from post-consumer plastics in Europe, recycled back into EEE is calculated to be <1% (RDC 2017). The plastic component of EEE increased from 14% in 1980

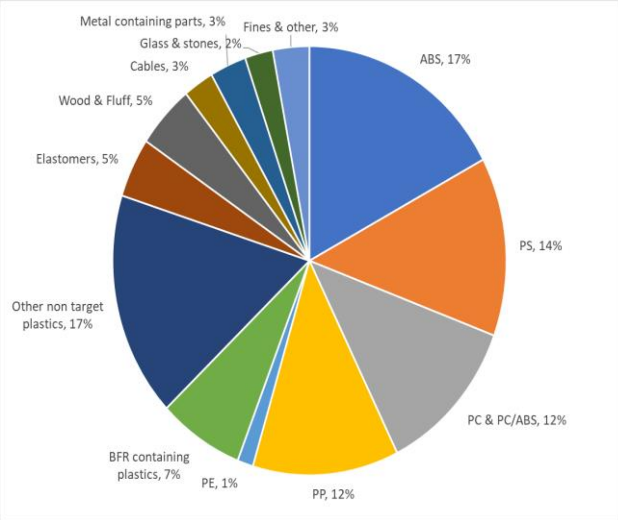
(Buekans & Yang 2014) to 20-25 % in 2015 (Huisman et al, 2016). Theoretically the total amount of plastic potentially available in the EU from all WEEE is 3.08Mt, based on a 25% plastics content (Huisman et al, 2016), however this includes WEEE that is currently not collected through compliance schemes. If total recorded WEEE is considered the plastic potentially available is around 1.08Mt. (derived from Balde et al 2017, Huisman et al, 2016) as shown in Figure 14.

Figure 14: Plastics in WEEE streams in 2016 in EU Approximation (derived from Balde 2017, RDC 2017, Huisman et al; 2016)

A recent study by EERA (EERA 2020) conducted by EERA expert Chris Slijkhuis also looked at what the current figures are on collection of WEEE in Europe based on the CWIT report (CWIT 2015) and the Urban Mine Platform figures (Huisman et al, 2016) and estimations based on the European WEEE market. This estimated that the considering the growth of the WEEE market since 2012 the WEEE plastics volumes are estimated to be 1.4 Mio MT – of which approximately 50 % from officially collected and report volumes. This study also demonstrates that the capacity for the treatment of this volume of WEEE plastics in Europe is much smaller than this volume.

Types of plastic commonly recycled from WEEE are PS, ABS, PC/ABS and PC (RDC 2017), these account for 56% of the plastics contained in WEEE (MGG 2020) as can be seen in Figure 15. Plastic convertors and manufacturers can ace challenges in sourcing post-consumer recyclate (PCR), some of these are discussed in the following MGG polymers business case study. Post production plastic wastes are largely redirected to back into the production process as they have high purity; however post-consumer waste is recovered on a significantly smaller scale (Wilts and Von Gris, 2016).

Figure 15: Average composition of WEEE plastics for recycling (2020): Source MGG Polymers



WEEE Plastics Mix	
ABS	17%
HIPS	14%
PC & PC/ABS	12%
Polyolefins	13%
Plastics containing BFRs	7%
Other Polymers and Elastomers	22%
Metal containing parts & materials	6%
Other organic contaminants	8%
Other inorganic contaminants	2%

There is a need to understand the wider context of how EEE is used and discarded in order to understand how the opportunities presented by the circular economy can be realised. In order to deliver a good circular business model, there is a need to identify the key resources and processes to deliver the value proposition to the customer (Johnson 2008). Those businesses operating in the circular economy should create value (EMF 2013). A holistic approach to delivering circular business models for the electrical and electronic equipment has the potential to maximise resources and deliver a more effective solution to the wider sustainability of the sector. Dematerialisation, harvesting of valuable components, materials and closed loop systems provide economic, social and environmental benefits to both industry and communities. The examples shown in this report show how some of the manufacturers and re-processors are realising the circular economy opportunity.

4.4.1 Business model for plastic recycler – MGG Polymers Case Study.

The MGG Polymers recycling plant started its commercial operations in 2006 providing a viable recycling alternative to incinerating WEEE plastics. These days the plant is one of the most advanced plastics recycling facilities in the world, with an area of approximately 20,000 m² and a capacity of 50,000 tonnes per year. The raw material source consists of mixed plastics from waste electrical and electronic equipment (WEEE). The plant operates around the clock and offers its customers a sustainable and consistent supply of high-quality Post-Consumer-Recycled (PCR) polymers enabling a growing market demand for more sustainable products. The key differences in fossil fuel derived products and recycled polymers are outlined in figure 16.

Figure 16: Comparison of high-tech polymers from fossil fuels versus high-tech polymers from recycled sources Source: MGG Polymers

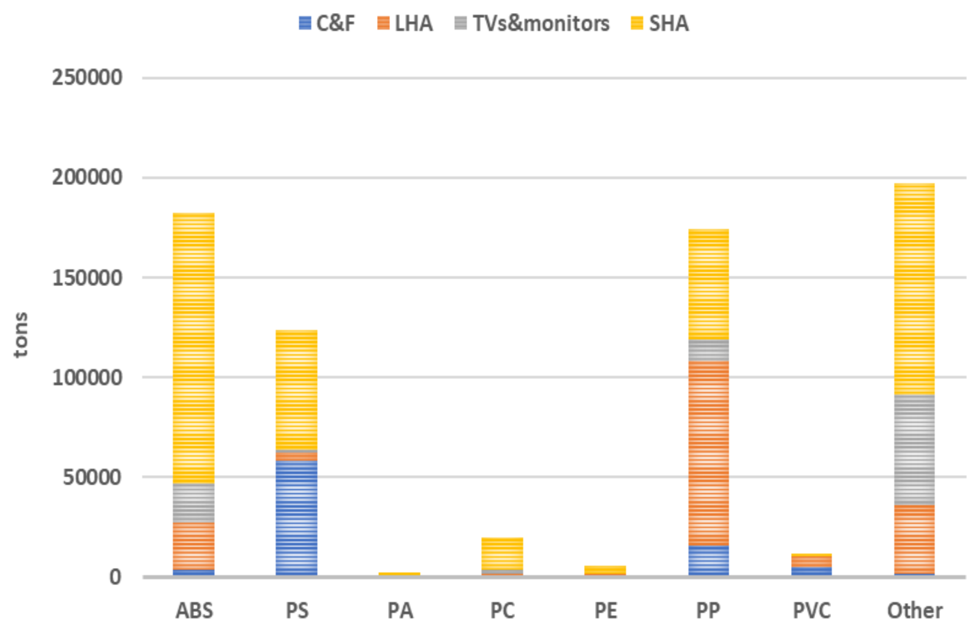
4.4.2 Enablers of the circular business model.

This plant produces high-quality post-consumer recycling (PCR) ABS, HIPS, PP and PC/ABS plastic resins from waste electrical and electronic equipment. As can be seen from figure 15 this constitutes 56% of polymers found in WEEE and the therefore the most common polymers needed to manufacture EEE. The plant relies on European collections of WEEE which are increasing due to EU legislations such as the WEEE directive (Directive 2012/19/EU). The differences in plastic composition of the WEEE categories defined by the EU WEEE directive are known so it is easier to know what you are getting as can be seen by table 4 and figure 17.

Table 4: Plastic (%) content of different WEEE flows. Reproduced courtesy of Ecodom 2019)

WEEE streams	***Cooling & Freezing***	***Large Household Appliances***	***TV & screens***	***Small Household Appliances***
Plastic content (%)	**12.98**	**14.00**	**16.42**	**36.40**

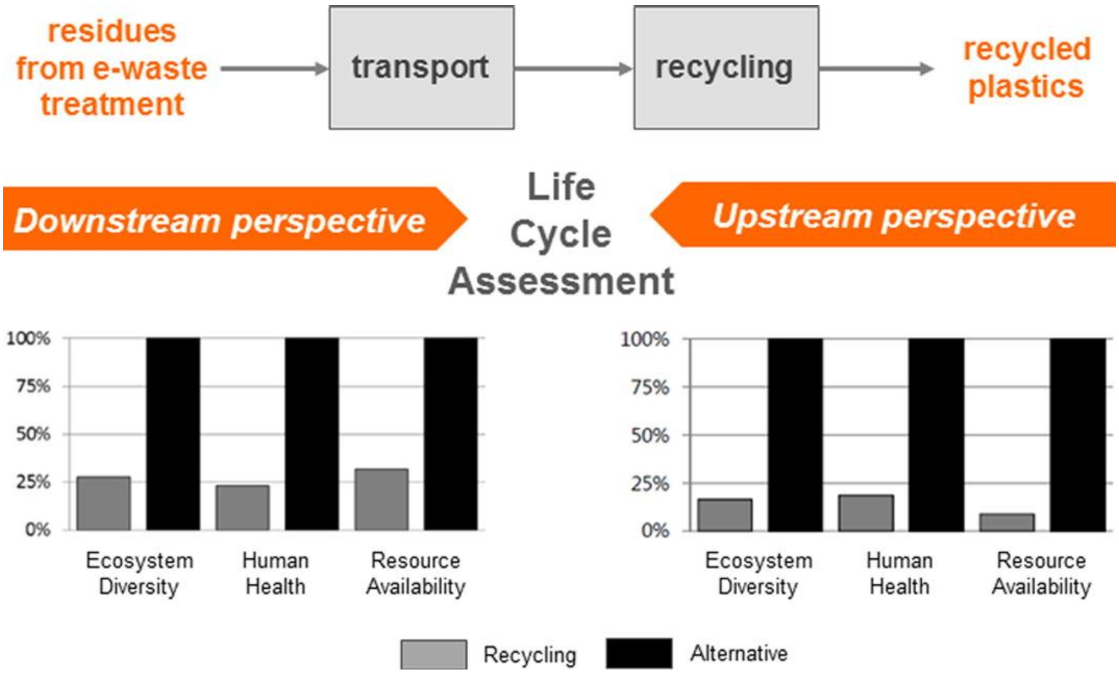
Figure 17: Available WEEE plastics in Europe. (Reproduced courtesy of Ecodom 2019)



These PCR resins are REACH and RoHS compliant and are used for a wide range of durable goods and "green" products, such as new electronic devices and automotive or office equipment, to just name a few of the applications. For the use in any new electric and electronic or other technical products, the quality and purity of separated plastics is a prerequisite. Once the purity and the quality of the separated polymer flakes is verified in a well-controlled quality management system, the separated flakes undergo a homogenization step before the extrusion and compounding process. The combination of the purity control, the homogenization and the professional extrusion and compounding steps using state-of-the-art extrusion lines, are the guarantee of a consistently high-quality post-consumer recycled (PCR) plastic.
The final PCR polymers are tested at the phase of plastic flakes and after the extrusion, not only on their rheologic and physical parameters, but also on their chemical compliance to both REACH and RoHS. A well-defined testing battery for each batch that has been developed over more than 15 years guarantees that the material is a stable drop-in replacement for virgin material.

The results of an LCA study (Wager and Hishier 2015) and shown in figure 18, show that the recycling of plastics from plastics-rich WEEE treatment residues has clear environmental benefits to alternative disposal and production routes. The recycling of plastics-rich WEEE treatment residues results in impacts that are about 4 times lower than those for the disposal in a Municipal Solid Waste Incinerator plant and 6 to 10 times lower than those for the virgin plastics production.

Figure 18: Graphical Abstract of Life Cycle Assessment of post-consumer plastics production from WEEE treatment residues in a Central European plastics recycling plant (Wäger and Hischer, 2015)



The high-quality tech polymers produced enable MGG to supply a growing demand from brand owners and manufacturers for a sustainable raw material alternative for production of their products. The polymers produced offer a technically feasible, price stable, environmentally beneficial alternative to fossil fuel derived polymers. The availability of these polymers therefore protects limited natural resources, reduces pollution of our environment and makes a significant contribution towards a circular economy.

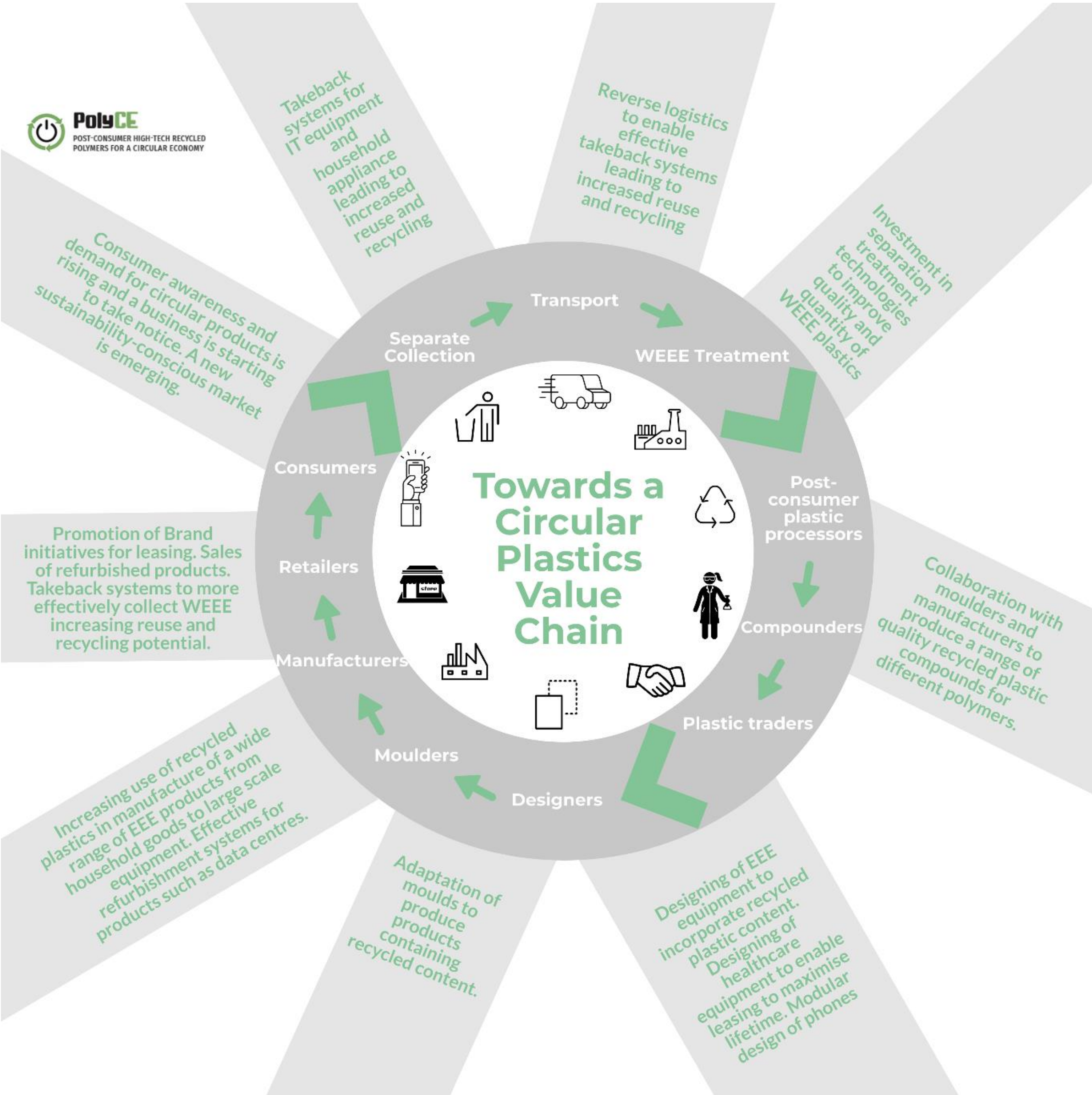
4.4.3 Current challenges of the business model.

The circular business model for re-processors is not without its challenges. Legislation means that moving collected WEEE plastics through the recycling supply chain across Europe, involves large amounts of bureaucracy. Only when it becomes a compounded material is it free to move like virgin material. The technology required to produce high-tech recycled polymers is complex and requires major investment.

Not all EU WEEE produced is collected. As can be seen in figure 14, over 50% ends up being either exported overseas, hoarded or ends up in general waste. While current EU directives require a steep reduction in WEEE plastics disposal, the recycling of such plastics should be weighed against the eventual risks related to hazardous ingredients (legacy brominated fire retardants and heavy metals). The conflict between the implementation of circular economy models and recyclates is likely to continue as new thresholds and toxicological parameters are introduced. There are many challenges which needs to be addressed so that recycling and recovery becomes environmentally sound with an aim to reducing the use of virgin materials.

Best practice from all the case studies and additional interviews are shown on figure 19.

Figure 19: A visual guide to current circular best practice in the value chain.



4.4 Circularity matrix and mapping.

In order to measure the impacts/ benefits generated by the adoption of circular strategies the adoption of circularity metrics is often adopted (Corona et al., 2019). However, no single "Circularity Metrics tool" is used by the OEMs and reprocessors to measure their circular economy performance. Ideally circularity metrics should provide an indication of how the principle of the Circular Economy is applied to a product or a service and most published circularity metrics have

been criticised for not representing the multidisciplinary nature of the CE (Saidini et al., 2017) Each business tends to have an individual approach in how it monitors its execution of its chosen circular economy approach using a variety of indicators based on environmental, economic and social performance across their entire value chain.
Summary descriptions of current indicators used by OEMS to measure circularity/environmental performance are highlighted below.

4.4.1 Philips.

Philips have a 5-year sustainability programme ‘Healthy people, sustainable planet’ in 2015 which built on their original Ecovision programme which was first used in 1994 (Philipsn,d.a). The program objectives are based on three pillars:

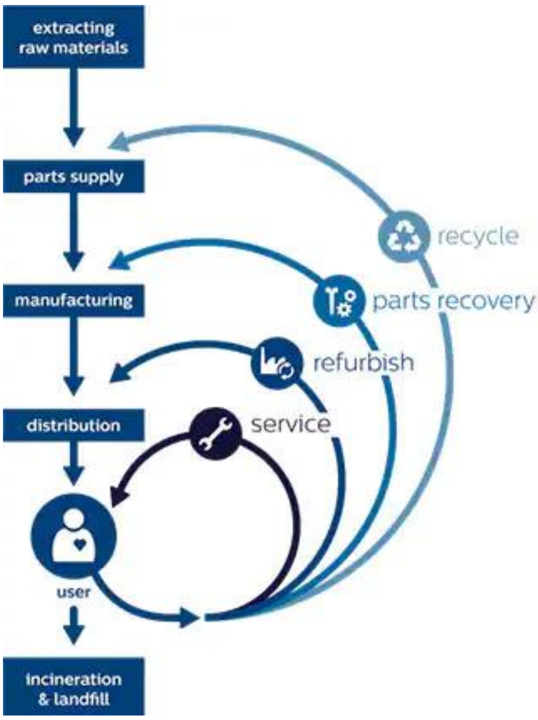
- creating value for Philips’ customers through sustainable solutions
- leading by example in its sustainable operations,
- by multiplying its impact by driving sustainability through its supply chain.

These are measured by Key Performance Indicators and are aligned to the SDG 12 Sustainable consumption and production and SDG 13 Climate action..

Key Performance Indicators for sustainable use of materials

1. ***Circular revenues*** - total revenue that the Philips organisation makes - aiming by 2020 for 15% of these revenues to come from CE business models. The following are recognised by Philips as CE models:

- Circular business models –any business model where Philips keep ownership of the product. That could be a lease, an access based or pay as you go business model.
- Refurbished equipment – Philips refurbish machines, the focus there is mainly on the big medical equipment.
- Revenue from refurbished components – Philips have some machines where there are certain parts that have a different lifetime, from the lifetime of the product, i.e. certain parts that need to be replaced. Refurbishment of just those parts is made possible, therefore don’t need to put in new parts. At the end of the of life the product is taken apart refurbished and resold as a refurbished machine.



2. By 2020 Philips are aiming to close the loop on all capital equipment. These are the large-scale medical machines e.g. the MRI machines and the IXRs,

3. By 2025 Philips want to extend that commitment to close the loop to all professional medical equipment.

4. Recycled plastics – Philips are aiming for products that have over 25% of recycled plastics in, parts where a recycled polymer is feasible to replace virgin plastics, (such as internal parts),

Philips do not expect that technology will allow them to use recycled plastics in skin contact and food contact parts these are likely to be available readily available polymers such as PP, ABS, HIPs and PC/ABS rather than technical plastics. As part a signatory to the Ellen Macarthur Foundation – “New Plastics Economy Global Commitment” (EMF 2019) they have pledged to use 10% recycled plastics (7600 tons).

4.4.2 Whirlpool.

Whirlpool follow the 9 CE strategies (the 9R’s) shown in Table 5 and the Circular Models defined by the EU Commission (Circular Design and Production, Circular Use, Circular Value Recovery) as shown in figure 20.

Table 5: The 9 CE Strategies 9Rs (Adapted from EU 2020)

1	Refuse	Make product redundant by abandoning its function or by offering the same function by a radically different (e.g. digital) product or service
R2	Rethink	Make product use more intensive (e.g. through product-as-a service, reuse and sharing models or by putting multi-functional products on the market)
R3	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
R4	Re-use	Re-use of a product which is still in good condition and fulfils its original function (and is not waste) for the same purpose for which it was conceived
R5	Repair	Repair and maintenance of defective product so it can be used with its original function.
R6	Refurbish	Restore an old product and bring it up to date (to specified quality level)
R7	Remanufacture	Use parts of a discarded product in a new product with the same function (and as-new-condition)
R8	Repurpose	Use a redundant product or its parts in a new product with different function.
R9	Recycle	Recover materials from waste to be reprocessed into new products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations

Circular Design

- Design products with increased resource efficiency (i.e. water /energy saving)
- Design products to be repairable and allow repair
- Develop alternative packaging materials with higher recyclability /recycling rate (internal targets)
- Substitute or reduce substances of concerns (internal target)

- Substitution of virgin with secondary RM (internal target)

Specific indicators are also assigned to certain activities:

- For packaging: developed an internal packaging scorecard
- For 2ndary RM: Circularity Indicator developed by WBCSD, adopted

Circular Use

- Refurbish (and sell as second hand) products damaged within supply chain. Returns Centres in the US, Canada and UK

Circular Value Recovery

- Cooperate within collective schemes across the EU to properly manage the EoL and treatment of appliances

Figure 20: Business Model Categories mapped on the value hill (reproduced courtesy of Whirlpool 2020)

4.4.3 Dell.

Natural Capital

Dell define Natural Capital as:

“The world’s stock of natural resources that makes human life possible and upon which businesses rely to produce goods and services.” Trucost (2015)

As businesses depend on both natural and renewable resources it is inevitable that a certain production of by products will need to be absorbed by natural capital and ultimately lead to long term economic and social consequences (e.g. climate change) and potential risk (physical, regulatory and reputational) for companies.

Quantification of environmental impacts allows for companies to attempt to account for some of these risks. Such activities which can be quantified include, internal operations, upstream supply chain and downstream product use and disposal. If impacts such as these can be converted into monetary values then metrics pertaining to value can be integrated within traditional financial assessment frameworks and performance tracking. The “net benefit” of a sustainability initiative can be determined by quantifying the difference between the effects of a more sustainable product, model or activity against traditional methods or “business as usual”.

At Dell the annual environmental impacts in natural capital values and “net benefit” of both Dell’s closed-loop ABS compared to virgin ABS and closed loop ABS and traditional PET were calculated. The method included a monetary value placed on human health, energy and fossil fuels, air pollution and water/ land pollution. It demonstrated that Dell’s closed-loop plastic had 44% ($1.3 million annually) greater environment benefit compared to virgin ABD while only a 1% ($17 000 annually) benefit over recycled PET.

Table 6: Natural Capital Values of Environmental Impacts; Virgin ABS & Closed loop ABS (Trucost, 2015)

Environmental impact		Virgin ABS	Closed-loop ABS	**Net benefit** of closed-loop ABS
Human health	Human health	-$1,045,000	-$392,000	+62%
	Respiratory effects	-$186,000	-$172,000	+8%
Energy & fossil fuels	Climate change	-$1,173,000	-$686,000	+42%
	Fossil fuel depletion	-$60,000	-$21,000	+65%
Air pollution	Smog	-$538,000	-$517,000	+4%
	Air pollution	-$82,000	-$78,000	+5%
Water & land pollution	Water pollution	-$44,000	-$28,000	+36%
	Ecotoxicity	-$14,000	+134,000	+1,057%
Cumulative		**-$3,143,000**	**-$1,760,000**	**+44%** **+$1,383,000**

Table 7: Natural Capital Values of Environmental Impacts; Recycled PET & Closed-loop ABS (Trucost, 2015)

Environmental impact		Recycled PET	Closed-loop ABS	**Net benefit** of closed-loop ABS
Human health	Human health	-$621,000	-$392,000	+37%
	Respiratory effects	-$132,000	-$172,000	-30%
Energy & fossil fuels	Climate change	-$543,000	-$686,000	-26%
	Fossil fuel depletion	-$20,000	-$21,000	-5%
Air pollution	Smog	-$367,000	-$517,000	-41%
	Air pollution	-$62,000	-$78,000	-26%
Water & land pollution	Water pollution	-$27,000	-$28,000	-4%
	Ecotoxicity	-$6,000	+134,000	+2,507%
Cumulative		**-$1,777,000**	**-$1,760,000**	**+1%** **$17,000**

It should be noted that in the application of this calculation data for the production of materials input was used in LCA modelling software and certain assumption were applied. The development of the "net benefit" of natural capital is dependent on individual scenarios and unless standardisation of assumptions is applied across a sector, comparison is ambiguous.

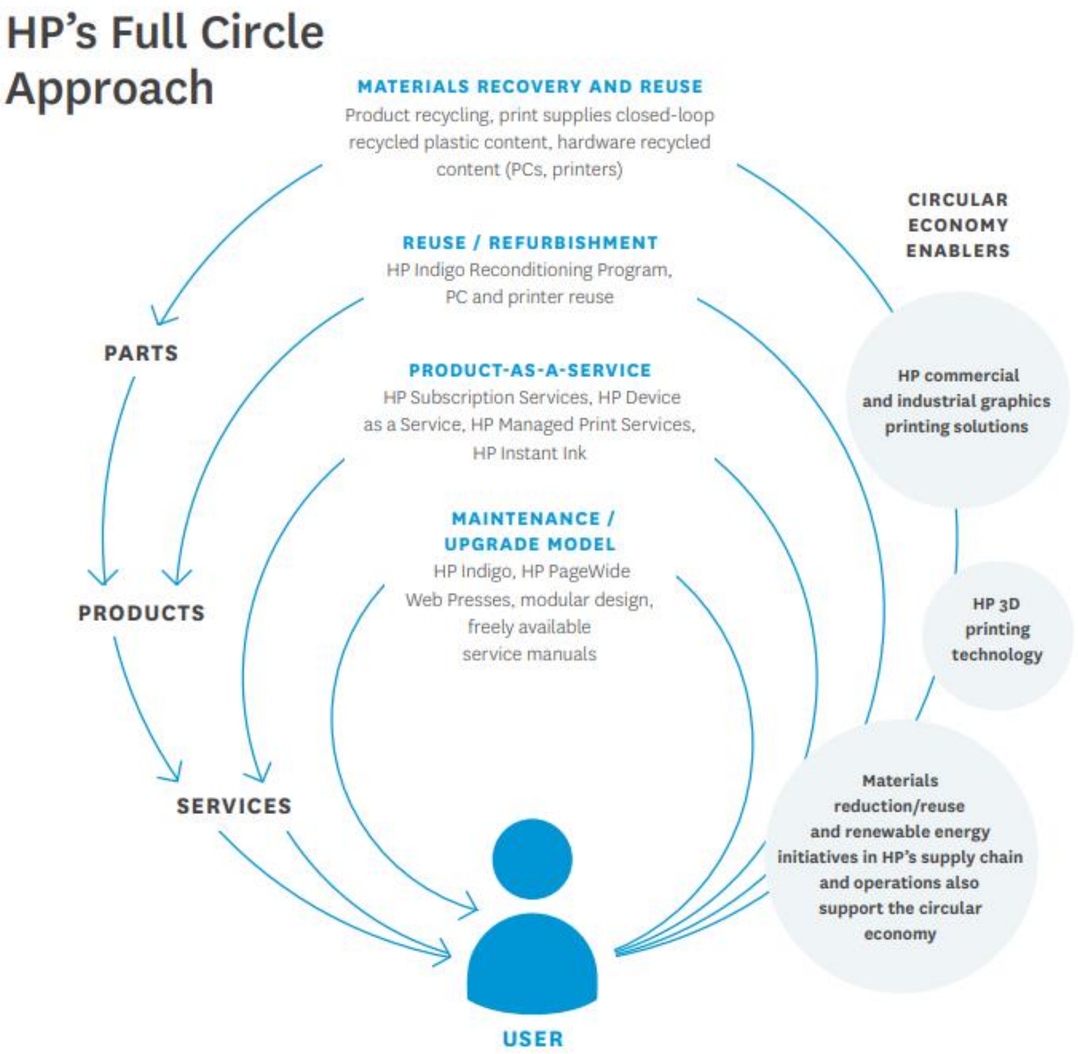
4.4.4 HP.

HP aspires to create “a world without waste” through the implementation of their sustainable Impact Programmes and aim to transform their entire business for a circular low-carbon economy. They align their Planet Sustainable Impact strategy to SDG 7, 12 and 13 and in 2018 they endorsed the European Strategy for Plastics and the French Circular Economy Roadmap and in 2019 they joined the Platform from Accelerating the Circular Economy (PACE).

Environmental Impact is measured using both GHG emissions and water consumption. These carbon and water footprints are based on product life cycle assessment -based estimates which aims to provide as a complete understanding of impacts across multiple levels or out supply chain from materials extraction through manufacturing and product use as well as retail and storage. These calculations use a combination of HP specific and industry methods and data.

With regards to waste HP work with production suppliers to improve waste measurement and reporting. Through this HP aim to reduce waste volumes and drive the circular economy. Following the HP Materials Strategy HP are moving forward to a Circular model of production and consumption using materials efficiently and responsible and recycling and reusing products at end of service. Currently they are developing peer reviewed ISO compliant LCA in order to fully understand the magnitude of benefits for their service-based solutions.

Figure 21: HPS Full Circle Approach towards a Circular Economy and low carbon model (HP, 2018)



- Pillar 1 decouple growth from consumption: keep materials in use at the highest state of value, reduce the resource used and repurpose materials properly.
- Pillar 2 disrupt industry business models - shift to serviced models and reduce waste and cost, extend product lifespan and increase reuse and recycling.
- Pillar 3 - digitise supply chains and production - for example, 3D printing technology, transforming the product design, manufacture and distribution, disrupt the traditional supply chain and create products and services in a more efficient and environmentally sound way

These are measures using the three pillars of sustainability People, Planet and Community each with specific goals.

Table 8: HP measures of success and long-term goals (adapted from HP, 2018)

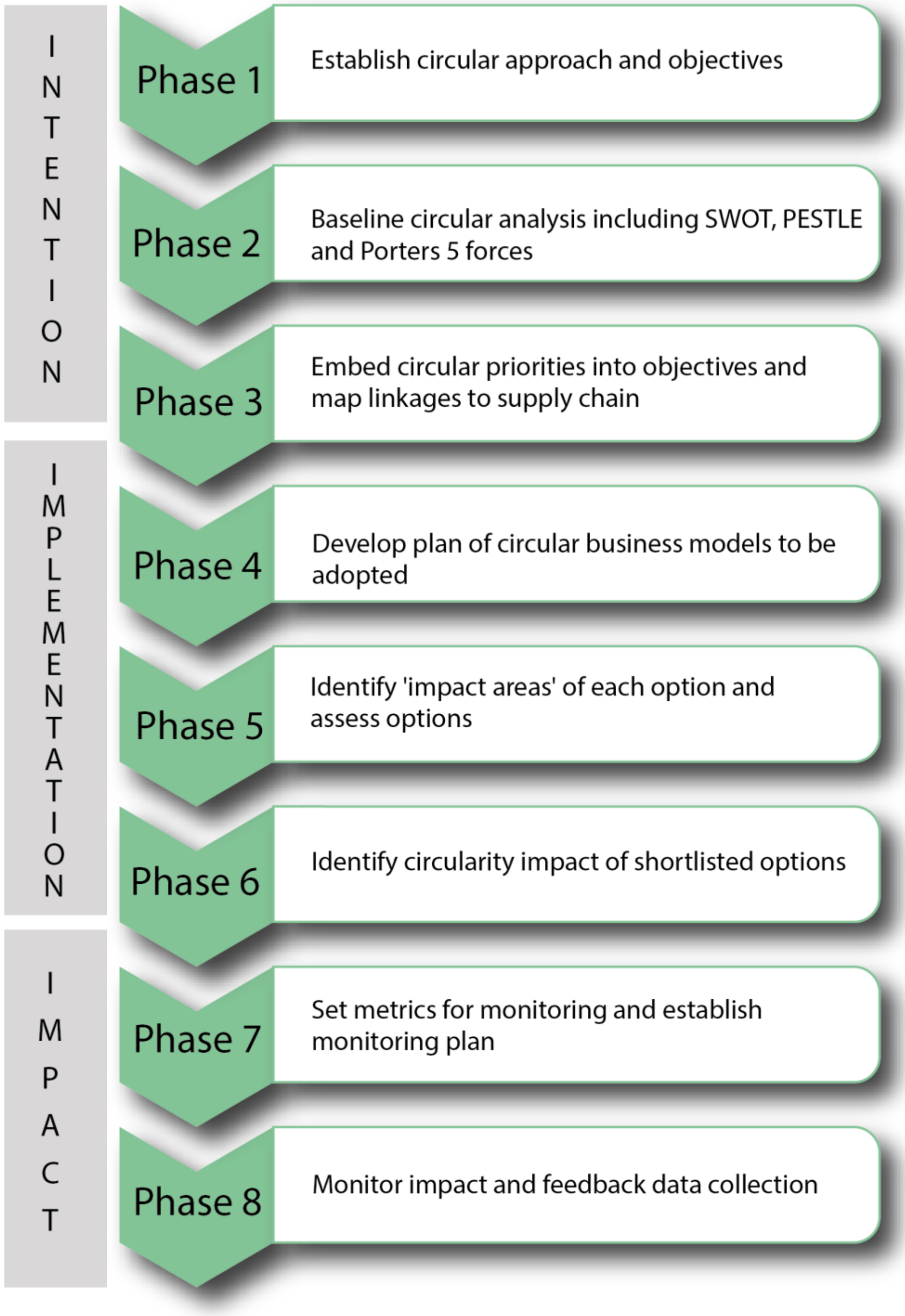
Planet	
Products and Services	**% goal achieved (as of 2018)**
• Use 30% post -consumer recycled plastic across HP's personal systems and print produce portfolio by 2025 • Reduce HP product use GHG emissions intensity by 30% by 2025 • Recycle 1.2 million tonnes of hardware and supplies by 2025	23% 27% 33%
Supply Chain	
• Achieve zero deforestation associated with HP brand paper and paper-based product packaging by 2020 • Reduce supply chain GHG emissions intensity by 10% by 2025 • Help suppliers cut 2 million tonnes of CO2 equivalent emissions by 2025	100% of goal achieved for HP brand paper 65% of goal achieved for paper-based packaging 0% 58%
Operations	
• Use 60% renewable electricity in global operations by 2025 • Reduce Scope 1 and 2 GHG emissions by 60% by 2025 • Reduce potable water consumption in global operations by 15% by 2025	78% 68% 40%
People	
• Develop skills and improve wellbeing of 500 000 factory workers by 2025 • Double factory participation in sustainability programs by 2025	51% 0%
Community	
• Enable better learning outcomes for 100 million people by 2025 • Contribute 1.5 million cumulative employee volunteer hours by 2025 • Enroll 1 million HP LIFE users by 2025 • Contribute $100 million in HP Foundation and employee community giving by 2025	21% 19% 17% 23%

4.5 Summary.

A review of current indicators used by OEMS to measure environmental/ circularity performance show that there is a range of methods employed. While companies are encouraged to come together in a pre-competitive environment to share best practices for movement towards a circular economy itis clear that each organisations journey towards circularity is unique and therefore comparison can only be done in a meaningful context and in careful consideration. Companies such as Dell and HP, focus on the environmental impact of the company with Dell reporting "net benefits" (in terms of natural capital) and HP aligning itself with "three pillars of sustainability. All OEMS report on circularity in terms of improvements or goals achieved, set against pledges and internal bench marks, and in relation to Philips and Whirlpool are keen to report in terms of individual products as well as looking at the company as a whole. It is noted that none report in terms of economic benefits and tend to cite the impact, in terms of benefits to sustainability, thus aligning directly with UN Sustainability Goals. There is no current consensus approach for how companies should measure their effectiveness in moving towards more circular business models, the development of Circular Transition Indicators (WBCSD) aim to provide an objective, quantitative and flexible framework (Van Brunschot, 2020) and compliment a company's existing sustainability efforts.

An interpretation of best practice from all of these examples from companies, of the steps in developing a circular product, has been collated and is shown in figure 22.

Figure 22: Phased development towards circularity for products



5 A Guide for Companies that would like to Start Integrating PCR Plastics into new Electronic Applications.

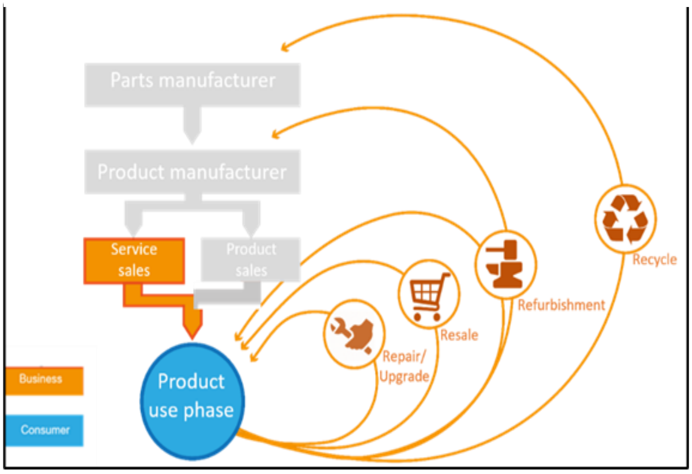
More and more companies decide to integrate PCR plastic into new EEE products. Electrolux uses 55 % recycled PP in vacuum cleaners (Electrolux Ultra Silencer vacuum) with savings over 2 liters of crude oil and 80 liters of water per unit as well as reduced manufacturing energy consumption by 90 %[30]. The German brand Grundig designed a vacuum cleaner made of 90 % recycled plastics originated from WEEE[31]. Philips designed a steam iron made of 30 % recycled plastics, a vacuum cleaner with 25-47 % recycled PP and a coffee machine with 13 % recycled plastics, while 90 % recycled ABS is in the baseplate and 40 % PP in the frame[32].

This shows that it is possible to replace at least a percentage of the amount of plastic in new electrical devices with PCR plastic. The use of this PCR plastic offers a number of political, social, ecological or environmental advantages, but can also reach technical or legal limits. The following section aims to inform the companies about the challenges and possibilities of the uptake of PCR plastic in new EEE products and to show them a kind of "first steps" in the right direction.

As already mentioned in chapter 4, five circular business models were developed: long-life model, modularity model, access model, service model and re-value model. When it comes to integrating PCR plastics into new electronic applications, the re-value model must be taken into account.

In the **Re-value Model**, companies are contributing to a CE by adding new value to products/materials that would otherwise be disposed. This can be done in a variety of ways, which all have in common that the ratio of product reuse is increasing. Thus, circular material flows are encouraged by treating discarded products or product parts as valuable input into a new value chain. The time of disposal is prolonged and material value is preserved.

Figure 23 The Re-Value Model (modified from Ellen Mac Arthur)



[30] https://mbapolymers.com/news/news-electrolux-vac/
[31] https://www.grundig.com/fileadmin/Export/Content/News/Product/2018/08_August/Grundig_Haushaltstechnologien_fuer_eine_Umwelt_mit_Zukunft.pdf
[32] https://www.philips.com/a-w/about/sustainability/sustainable-planet/circular-economy/recycle.htm

Besides repair upgrade, reuse and refurbishment this CBM also covers high-quality plastic recycling and thereby serve as a theoretical foundation for the uptake of PCR plastics in new electronic products, covered in the following section.

3.1. PESTLE Analysis of the uptake of PCR plastics in the electronics sector.

With the help of a PESTLE analysis it is possible for businesses to take a closer look at the macro environment of business strategies regarding specific market conditions, (probable) developments as well as their effects in order to assist company management in their decision-making processes. The macro environment has a significant influence on the strategy development of a company. PESTLE stands for **p**olitical, **e**conomic, **s**ocial, **t**echnological, **l**egal and **e**nvironmental factors. (Theobald 2016)

The different factors associated with a shift from using exclusively virgin plastics to integrating PCR plastics are elaborated here to provide companies with an overview on the expected macro environmental aspects related to this strategic decision, see figure 24.

Figure 24: Influencing factors of PESTLE analysis regarding PCR-plastics

Political factors.

Political winds in Brussels have focused on the packaging industry lately and can be perceived as being the strongest factor for pushing single industry sectors towards increased plastic recycling in Europe. The European Commission has claimed that by 2030 at the latest, plastics that cannot be recycled should no longer be used in the EU, in an attempt to drastically reduce the plastic waste in the future, much of which has been burned, landfilled or illegally discarded into the sea.[33]

The European Commission set higher **collection and recycling targets** to increase the amount of WEEE to be treated and therefore more WEEE plastics are available for recycling. From 2019 the minimum collection rate rose from 45% to 65%. (European Commission 2012) In addition, large amounts of WEEE plastic must be treated in Europe, since the **china ban** prohibits the import of plastic waste (Wagner et al. 2019).

The European Federation of Waste Management and Environmental Services is continuously advocating for concrete and strong policy measures, such as mandatory green public procurement, binding recycled content in certain products, reduced VAT for products composed of recycled content, and eco-design aspects. Vice Commission President Frans Timmermans argues that an EU-wide tax on virgin plastics will be extremely difficult to establish pinpointing to the fact that some plastic use is indispensable. However, through incentives and innovations, but also through prohibitions, Brussels wants to make plastics not only better: the only long-term solution he sees is to reduce plastic waste by increasing its recycling and reuse.[34]

The **European strategy for plastics in a Circular Economy,** published in January 2018, aims to push the EU to a circular plastic economy, to support more sustainable production patterns for plastics, to support the reuse, repair and recycling of products as well as to reduce marine litter, greenhouse gas emissions and dependence on imported fossil fuels (European Commission 2018). To push the uptake of recycled plastics, Annex III of this strategy includes voluntary pledges of 70 companies and business associations defining their contribution with a goal that 10 million tons of recycled plastics find their way into new products by 2025 in the EU (European Commission 2018).

In December 2019, the **European Green Deal** was announced which aims for no emissions of greenhouse gases until 2050 and to decouple the economic growth from resource use (European Commission 2019). One of the main blocks of the Green Deal is a **Circular Economy Action Plan**, which was published in March 2020 and provides a future-oriented agenda for achieving a cleaner and more competitive Europe. The Action plan announces initiatives along the entire life cycle of products, targeting the design of sustainable products,

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[33] https://www.welt.de/wirtschaft/article172554048/EU-Strategie-Ab-2030-sollen-Plastikflaschen-verbannt-sein.html

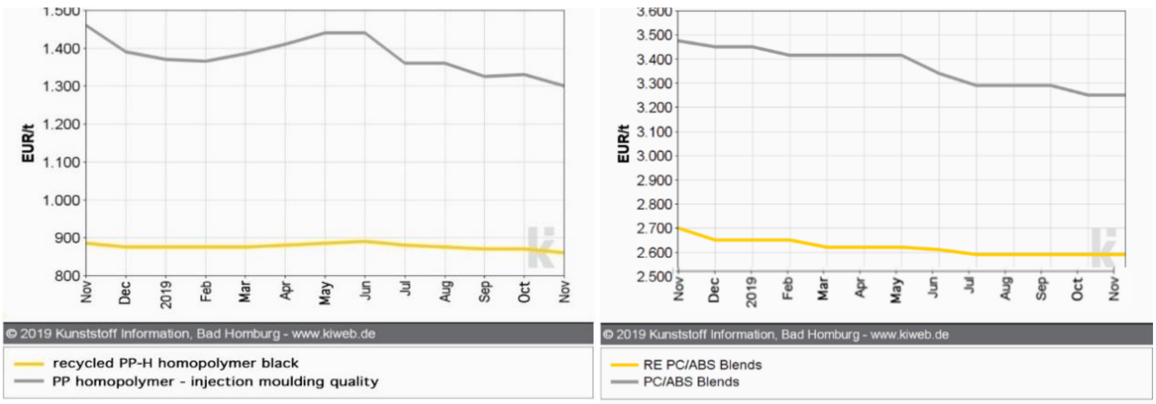
[34] https://www.theguardian.com/environment/2017/oct/06/eu-rules-out-tax-on-plastic-products-to-reduce-waste

promoting circularity in production processes, supporting sustainable consumption and aiming to ensure that the resources used are kept in the EU economy for as long as possible. (European Commission 2020) One of the strategies to increase the uptake of recycled plastics could go along a requirement for minimum recycled content in new products as well as waste reduction measures. Current and future political initiatives are very much in line with the strategy that support the integration recycled plastics into new electronics applications, thus manufacturers that chose this path are actively supporting the current political CE Initiatives in Europe.

3.2.1 Economic factors.

A decisive advantage for using PCR plastics from an entrepreneur's point of view is the more **stable market price with lower fluctuations**. Figure 25 shows the monthly data from "Kunstoff Information" with two commonly used types of plastic, PC/ABS and PP. The graphics clearly show that in 2019 recycled plastic equivalents had a market price around 30-50 % below the price of primary plastics and show fewer price fluctuations. Both observations are of interest to companies. Case studies have shown that the use of plastic recyclates can be profitable for companies, especially in the long term, with increasing experience and if PCR plastic materials remain below the virgin plastic price. (Emmerich 2020). It remains to be seen whether a future increase in demand for plastic recyclates would result in rising prices and if a drop in oil prices could change the price advantages of recycled material. Lower price fluctuations mean more planning security in the long run on the cost side in line with more market stability.

Figure 25: Polymer costs of recycled PP and PC/ABS and virgin equivalents (KunststoffWeb 2019)



In their strategic decisions, OEMs depend on input factors such as quality, quantity and price of the raw material. Lower raw material costs consequently result in lower manufacturing costs and lead to a higher profit rate. Since the recycling industry can meet the quality requirements for many electronic applications, certain plastic components can be replaced by recycled equivalents in the future. However, it must be emphasized that the quantities that are currently on the market do not provide a substitute for primary to secondary plastics as a mass scenario yet, and that a significant increase in secondary plastic material in adequate quality will be necessary in the future.

Although the **market for recycled plastics is developing rapidly, it is still small**. One reason is still the lack of demand for recycled plastics by manufacturers. As a result, investments in better separation technologies are met with resilience and large quantities of WEEE plastics remain unrecovered. (Chancerel et al. 2019; Vlugter 2017) The underlying question of who will pay for the extra cost of investments that are necessary to boost the PCR plastic market remains open. Currently recyclers are left alone with higher investment costs which could be one reason for the PCR market still lagging behind. A shift from virgin to PCR plastics will remain difficult as long as demand remains low and policy do not provide incentives to increase the content of recycled plastics in products.

3.2.2 Social factors.

Investigations conducted on the consumer side have revealed that the **most relevant social aspect affecting the low demand for EEE containing recycled plastics is the lack of knowledge and lack in awareness by consumers regarding recycled plastics in electronic devices.**

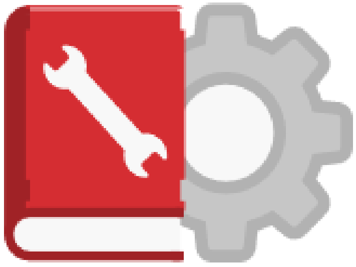
However, a **consumer survey** conducted in the framework of PolyCE, revealed that consumers are becoming more aware of the positive aspects of adopting circular consumption models, especially when it comes to the negative effects related to the plastic waste problem.

A social experiment was conducted in the course of the PolyCE project, as part of a consumer awareness raising campaign to highlight the benefits of recycled plastics in electronics[35]. The experiment took place on the streets of Brussels, in June 2019, whereby random passers-by were approached and asked to compare two vacuum cleaners displayed on a stand on the street and find differences in their appearance and functionality. They were given information on their components and technical specifications. Participants were faced with two vacuum cleaners looking exactly the same, the only difference being the plastic components (one with- and one without recycled content). Consumer did not notice a difference, moreover many were stating their readiness and willingness to purchase a vacuum cleaner containing recycled plastics if available in the shop. When asked to guess the amount of recycled plastic content in current electronic products, many where shocked to find out that the overall percentage is still only around one percent today. It seems that consumer awareness, especially amongst young adults, is changing into more environmental conscious buying behaviour that would be in favour of product containing recycled plastics.
The uptake of recycled plastics into new electronic products is not only a choice for sustainability- it provides a company with a competitive advantage over market players who

[35] The full video is available at: https://www.youtube.com/watch?v=edeIoy1dP94

remain linear acknowledging the raising environmental awareness of consumer to help in fighting global plastic waste. The company gets a positive record by doing sustainability and Corporate Social Responsibility (CSR). CSR is a voluntary contribution of the company to sustainable development, which goes beyond the legal requirements and includes among other issues such as environmental protection, environmentally responsible production and procurement (Sandberg und Lederer 2011).

3.2.3 Technological factors.



When it comes to technological factors, it is important for manufacturers to know the challenges and possibilities of PCR plastics for their products.

An important challenge at the downstream stage are the **requirements for the integration of PCR-plastics into new products like aesthetics, functional properties, colour or smell.** Plastics used in specific products have to fulfil target properties for the application which differ from one company to another. PCR plastics have to meet these technical requirements in order to enable its future uptake. When it comes to **aesthetical challenges of PCR-plastics**, a high-quality visual appearance including colour and surface properties (gloss, matt, etc.) pose some of the major challenges for manufacturers and designers working with recycled plastics. Since the visual appearance is a key priority for electric and electronic goods, it is necessary to fulfil these requirements with recycled materials when applied for visible parts (Mbarek et al. 2019). There are several factors which pose a challenge for recycled material returning from the WEEE stream. First of all, the broad variety of coloured PCR plastics is a limiting factor for specific colour requirements. However, it has been proven that the quality of recycled plastics improving rapidly and compounders are able to produce a broad spectrum of coloured and high gloss products also with recycled materials. (Mbarek et al. 2019)

When it comes to material properties of PCR-plastics, the material tends to change during recycling. The polymer itself and the conditions during its lifetime and processing determine which material properties are being altered more and which less. Therefore, a good knowledge about the degradational effects of the individual polymer is crucial. As an example, ABS is one of the most effectively recycled polymers within WEEE recycling. However, it is sensitive to degradation. Mostly affected are impact strength and ductility. In this case, restabilisation through adding virgin material or additives like impact modifiers are promising solutions to obtain a good product. (Rageart et al. 2017). This holds for most polymers, just the type and amount of virgin material and additives varies dependent of the polymer and the final product specifications.
In case of material characteristics, **four types of PCR plastics can be effectively recycled from WEEE** namely Polypropylene (PP), Polystyrene (PS), Acrylonitrile-Butadiene-Styrene (ABS) and Polycarbonate-ABS (PC-ABS). Each plastic type has its own characteristics which have to be taken into account during the moulding in production process.

When it comes to the **processing of PCR plastics in the production process, injection moulding** represents the most important technique to produce polymer formed components. When the company progresses towards introducing recycled plastics in new products that still need to be launched, companies should ensure that the **mould is optimized for material properties:**

- Do ensure good venting of the mould
- Do not go for very thin walled mould design
- Do consider texturing parts to mask visual limitations of recycled plastics

In comparison to virgin plastics there are several crucial differences which can lead to defects in the final product. First, it is important to keep in mind that PCR plastics come with technical data sheets, however only showing the general properties (this is the same for virgin). Specific material properties are requested by the manufacturer who will do material property testing on product level. During the process itself mild processing is the key for a good result. Whilst virgin material can be processed at higher rates, pressure, temperature etc. for high efficiency and still obtain the desired quality, PCR plastics are more sensitive. High screw shear forces, temperatures and pressure can further degrade the recycled polymers (Höggerl 2019).
The production of odorous substances can stem from a variety of sources. External contamination of the plastic in its previous use is perceived as the main cause for smell but also the production of odours during processing poses a challenge. It is self-evident that a product cannot be sold holding these olfactory characteristics (Strangl et al. 2017). Momentarily there are several existing methods to counteract this problem and many more are in development. Known methods for odour reduction in recycled materials are contacting PCR plastics with hot gas under vacuum, the addition of further substances or stripping of volatiles (Wypch 2013). Furthermore, a gentle re-processing could reduce smell of recyclates at least for PE (Bravo und Hotchkiss 1993).

Since PCR plastics could contain certain impurities including a low percentage of substances of concern, applications for food contact, toys or medical devices are not suited for PCR plastic uptake (Berwald 2018). It is advisable to start the replacement of virgin components with recycled equivalents for non-visible inner parts. With increasing testing and technical experience, manufacturers can in the longer run also replace outer, visible parts with PCR plastic material.

3.2.4 Legal factors.

When it comes to legal factors, **several regulations are in place for EU actors, like the Restriction of hazardous substances (RoHS), the WEEE-Directive as well as the REACH and POP Regulation**. By this regulatory requirements, WEEE recycling facilities and EEE manufacturers are often faced with difficulties like dealing with plastics parts that contain brominated flame retardants (BFR). The EEE industry is generating a limited amount of plastic products with BFR which have to be properly separated by pre-processors and recyclers to enable the re-use of PCR plastics in new products. However, recycling technologies today are increasingly being developed to detect and remove substances of concern (SOC) from the plastic waste streams, followed by a secure elimination to remove SOC from the value chain. Furthermore, pre-processors and recyclers are widely aware of the waste stream categories and even the plastic parts that need special handling to avoid SOC entering the mix of materials to be recycled.

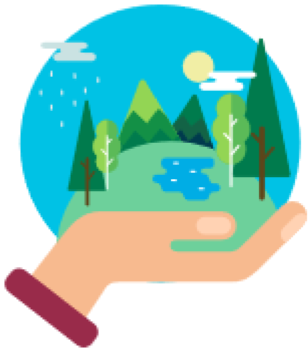
Table 9: Average composition of WEEE plastics

WEEE Plastics	
ABS	24 %
HIPS	27 %
Polyolefines	7 %
PC and PC-ABS	7 %
BFR containing plastics	5 %
Other plastics	24 %
Other contaminants	6 %

Today, there are still WEEE plastics, which contain restricted BFR. However, a minority of these plastics actually contain POP substances. By far the majority of the WEEE plastics does not contain Brominated Flame Retardants (BFRs) and of the approximately 5-10 % that do contain BFRs, only approximately 30 % consists of POP BFRs (see table 9) (Slijkhus 2016).

Regarding the **design for recycling approach**, there are currently no significant considerations to use PCR plastics in the **manufacturing of new products within the legal framework 2009/125/EC Energy-related Products (ErP) Directive** (European Commission 2009). Focus of this directive is to reduce the environmental impact caused during the manufacturing, use and disposal of products as well as general requirements on energy consumption (Wagner 2018). Nevertheless, discussions are ongoing whether a minimum recycled content for plastic should be introduced in new products to stimulate secondary plastic markets. Experts claim that it might only be a matter of time before recycled content is implemented in legislation e.g. in form of a minimum recycled content for new EEE products. Companies that deal early with the integration of PCR plastics in new products would be well prepared for this change and can deal with the implementation of the new recommendations more easily and quickly.

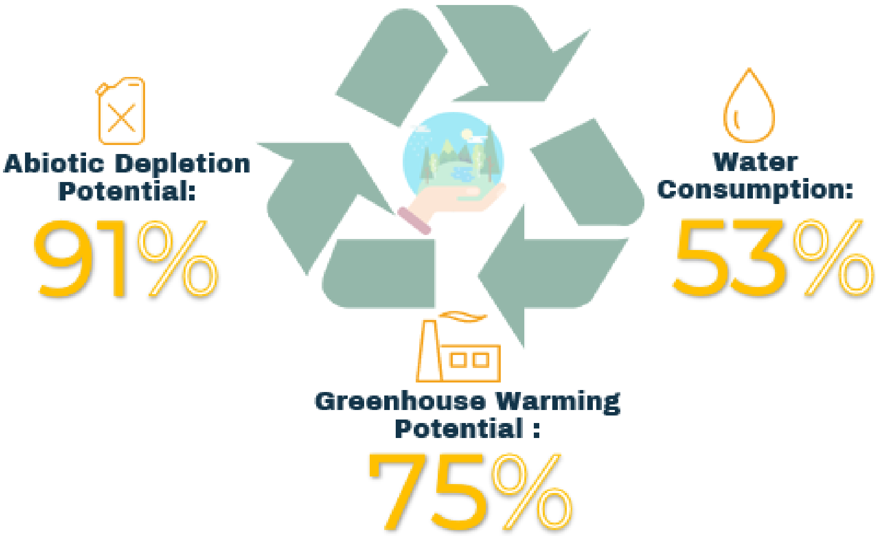
3.2.5 Environmental factors.



Compared to virgin plastics, **the recycling of plastics is saving large amounts of CO_2 emissions and energy** (EERA 2018). An estimated CO_2 reduction of the compliant recycling of all plastics from WEEE in Europe according to the standard EN 50615-1 is about 2.5 million mega tonnes of CO_2 per year (EERA 2018).

A study in 2015 concluded that **PCR plastics have less than 20 % of the global warming potential (GWP), compared to virgin plastics** from the primary production. (Wäger und Hischier 2015) An investigation in the PolyCE project of the life cycle assessment (LCA) of virgin and recycled plastics **compare the environmental performance of post-consumer recycling of PP and PS from WEEE** with a respective conventional approach. The environmental performance of the resulting PCR PP and PCR PS from the PolyCE approach show that the GWP of 1 kg PCR PP is 75 % lower compared to virgin PP (see Figure 26). Furthermore, the need of water for the production of PCR equivalent is 53 % lower and the abiotic resource depletion potentials (ADP) is 91 % lower than the virgin production. (Gaspar Martinez 2019)

Figure 26: Saving potential of using recycled instead of virgin plastics from WEEE according to (Gaspar Martinez 2019)



3.3 SWOT analysis for integration of PCR plastics into business strategies.

A **S**trength **W**eakness **O**pportunities and **T**hreats (SWOT) analysis is a fundamental tool in strategic planning for companies to identify the internal and external organizational environments (Chermack und Kasshanna 2007). The analysis consists of investigations to internal competences and capabilities such as building upon strength and eliminating weakness and external positive and negative circumstances such as exploit opportunities and mitigate the effects of threats (Chermack und Kasshanna 2007).

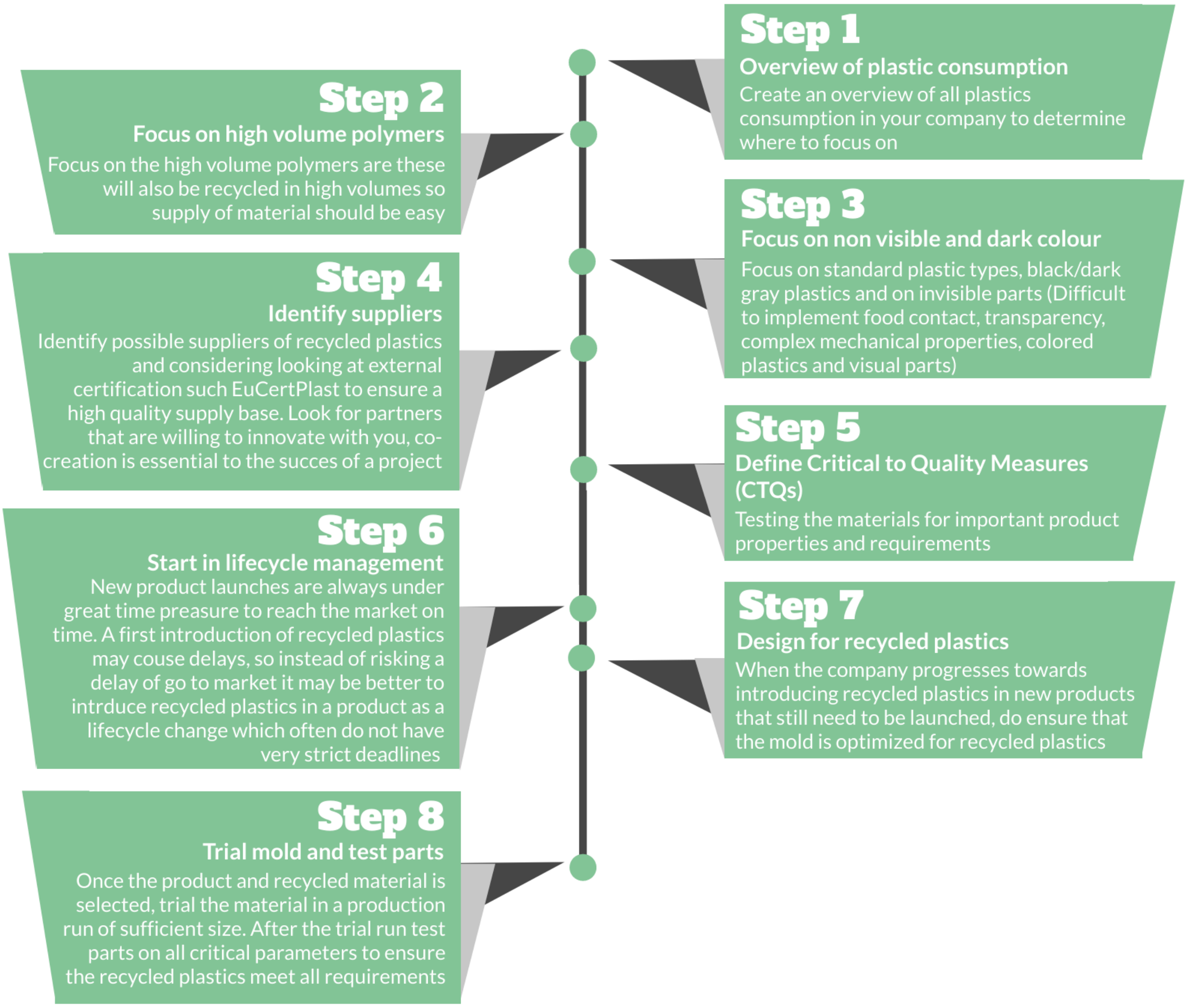
Table 10: SWOT - Analysis for integration of PCR plastics into business strategies

Strengths		**Weaknesses**	
S1	Better price predictability of more stable PCR plastic prices and potential cost savings when PCR prices are lower compared to virgin material	W1	Lack of experience in producing and moulding with PCR material
S2	Manufacturing of new products within the legal framework in the future (ErP-Directive)	W2	Young and still immature market for recycled plastic compared to virgin plastics
S3	Sustainability and Corporate Social Responsibility (CSR) of the company	W3	Limitation in material characteristics (colour, gloss, odour or food contact considerations) and constraints in the application of outer parts
S4	Saving of CO2 emissions and energy helps mitigating global warming	W4	Rearrangement of some process parameters due to differences in material properties (melting points and processing temperatures) of recycled plastics
S5	Respond to increasing environmental awareness on plastic waste from consumers	W5	Technical data sheets of PCR plastics not always are reliable: need of retesting the material before using it (cost implication)
S6	Reduce dependency on imported materials		
Opportunities		**Threats**	
O1	Improved material experience and improved company resilience due to flexibility in material use	T1	To fulfil several regulations requirements (WEEE-Directive, RoHS-Directive, POP-Regulation, REACH-Regulation, etc.) with difficult minimum thresholds
O2	Constantly improving recycling will help to boost high quality PCR plastics in the future	T2	Consumer perception of recycled plastics in some social groups remain critical
O3	Actively working in line with current EU policy to support the use of PCR-plastics in EU CE strategy	T3	Stable PCR market still lagging behind
O4	Rapidly developing markets and material availability with increasing WEEE waste streams in Europe	T4	Instability of material volume and availability
O5	Taking on a pioneering role in sustainable business strategy and waste reduction	T5	Reduced oil prices may lead to cheaper virgin plastics
O6	Establishment of strong European recycling industry in response to the China ban		

3.4 Enabling factors and Concrete Steps for interested companies.

The following eight steps in figure 24 were developed by a consortium partner (Philips) to give the companies a kind of guideline on what to consider when taking up recycled plastics into new electronic products (Smit 2019):

Figure 27: Eight steps to start integrating PCR plastic in new electronic products according to (Smit 2019)



3.5 Sales Pitch.

As part of the PolyCE project, a sales pitch (Annex II) with the title *“Going Circular! A pledge for recycled plastics in new EEE applications: a strategic company choice”* was created to promote the advantages from a manufacturer´s perspective on using PCR plastics in new EEE products.

The sales pitch deals specifically with the competitive advantage of plastic recycling and the needed change in the field of plastic use. The current WEEE plastic stream and plastic recycling market is illustrated together with a market overview of PCR plastics . Possibilities are shown, which properties can already be achieved with by using PRC plastics in new EEE products and which challenges remain. The sales pitch shows the economic and environmental benefits for the companies and highlights the overall advantages of the use of PCR plastics in the electronics sector. To help the companies starting a change towards CE and the use of PCR plastics in their electronic products, first steps are given as a first guidance for interested companies.

The sales pitch shows the companies the golden opportunity that the uptake of recycled plastics into new electronic products entails and highlight the aspect that it is not only a choice for sustainability- working with PCR plastics provides a company with a competitive advantage over market players who remain linear.

ANNEX I

1. **Consumer survey aims and methodology of the comparable study.**

As part of the preparatory phase and literature review behind task 9.2 of PolyCE, in 2018 UNU launched an online consumer survey in the English language in 2018. The survey was consequently translated into five European languages[36].

The aim of the exercise is to study European consumers' attitudes towards recycled plastics and the Circular Economy (CE) as a whole. Additionally, the consumer survey delves into European consumers' awareness and level of engagement with the Circular Economy, along with their attitudes towards recycled plastics in electronics. The results of the survey serve the needs of task 1.3 of PolyCE, and aid in understanding and identifying the potential of new circular consumption habits for dematerialization of plastics from electronic waste.

The main target audience of the survey includes the following stakeholders:

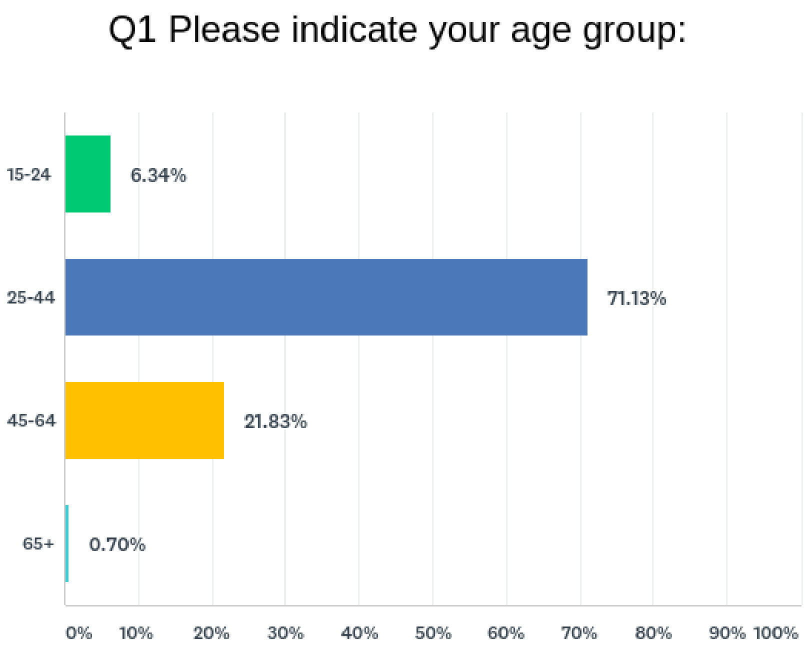
- General public, and particularly European consumers between the ages of 15 and 65
- Consumers' organisations
- Campaigners, NGOs
- Progressive businesses
- National authorities (municipalities, school, universities)

The results reported in the analysis-related section are currently based on 147 responses of the English version of the survey, as of April 2020.[37]
The completion rate, meaning the percentage of survey takers that completed the entire survey, is about 80%.
More than 7 out of 10 respondents are aged between 25-44 (71.13%); the second most represented category is 45-64 years old (21.83%), followed by 15-24 (6.34%) and only 0.7% of people aged 65 or older.

[36] French, Spanish, Italian, Dutch and German.

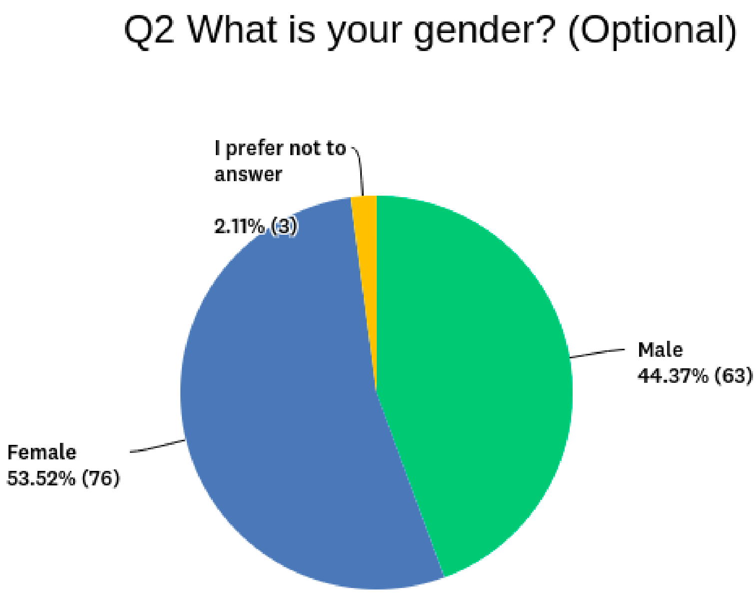
[37] The PolyCE consortium is currently promoting the survey on different channels, to try to enlarge the number and types of participants and further update the overall picture before the end of the proejct.

Figure 28: Age distribution of respondents. Source PolyCE Survey (2020)



The gender of the respondents is quite balanced, with a slight predominance of female, 53.52% vs 44.37% of male respondents, and 2.11% who preferred not to answer.

Figure 29: Gender distribution of respondents. Source: PolyCE Consumer Survey (2020)



In terms of 'average' household composition, the majority of respondents (81.94%) are in households of 2-5 people, with an overall income of 20 - 80,000 EUR (62.5% - corresponding to the two main range categories of 20-50k and 50-80k EUR, respectively 35.42 and 27.08%). The graphs below show in detail the relevant data concerning the income and the households' size.

Figure 30: Household members. Source: PolyCE Consumer Survey (2020)

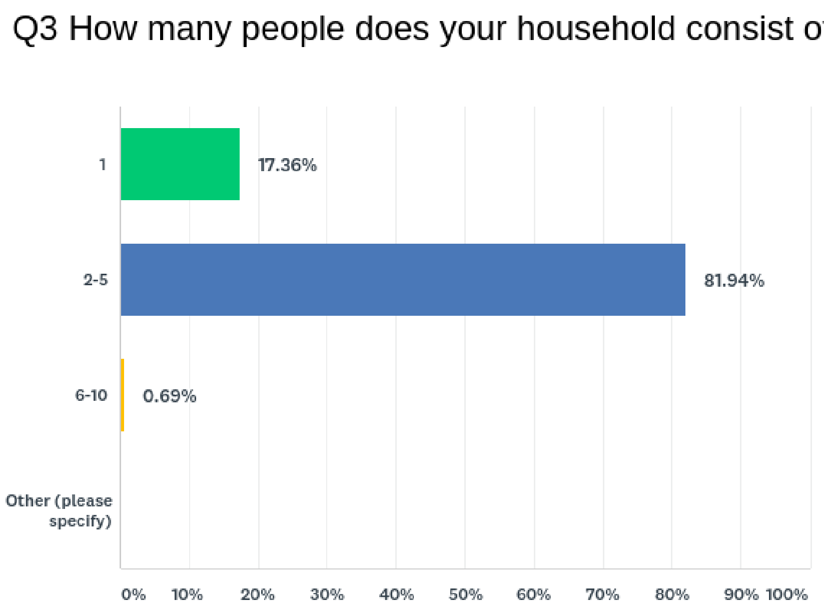


Table 11: Income. Source PolyCE Consumer Survey (2020)

ANSWER CHOICES	RESPONSES	
Less than EUR 20.000	8.33%	12
EUR 20.000 to 50.000	35.42%	51
EUR 50.000 to 80.000	27.08%	39
EUR 80.000 to 110.000	11.81%	17
EUR 110.000 to 140.000	5.56%	8
EUR 140.000 to 200.000	10.42%	15
EUR 200.000 and more	1.39%	2
Total Respondents: 144		

Quite in line with the overall information on the 'economic status' of the households represented in the sample, the educational level of the respondents is, generally, elevated: more than half of the respondents (57.64%) held a master or similar and 18.06% held either a PhD or a Bachelor degree.

In terms of geographical coverage of the survey, due to the nature of the project PolyCE, almost the totality of the respondents is based in the EU - besides 3 respondents who were based in the US and 1 in South Korea. The main countries covered are mostly linked to the project network, and include Belgium, the Netherlands, France, UK, Italy, Spain and Bulgaria.

Respondents from Slovakia, Serbia, Denmark, Portugal, Sweden, Austria, Greece and Finland are also counted.

2. Analysis of the survey results

In the introduction of the PolyCE survey, the general level of awareness concerning the issue of circular economy was investigated. It is worth noting that almost 8 out of 10 respondents (78.91%) to the PolyCE consumers' survey declared to be 'very familiar' with the concept of circular economy (CE); while only the 5.44% were not familiar at all.

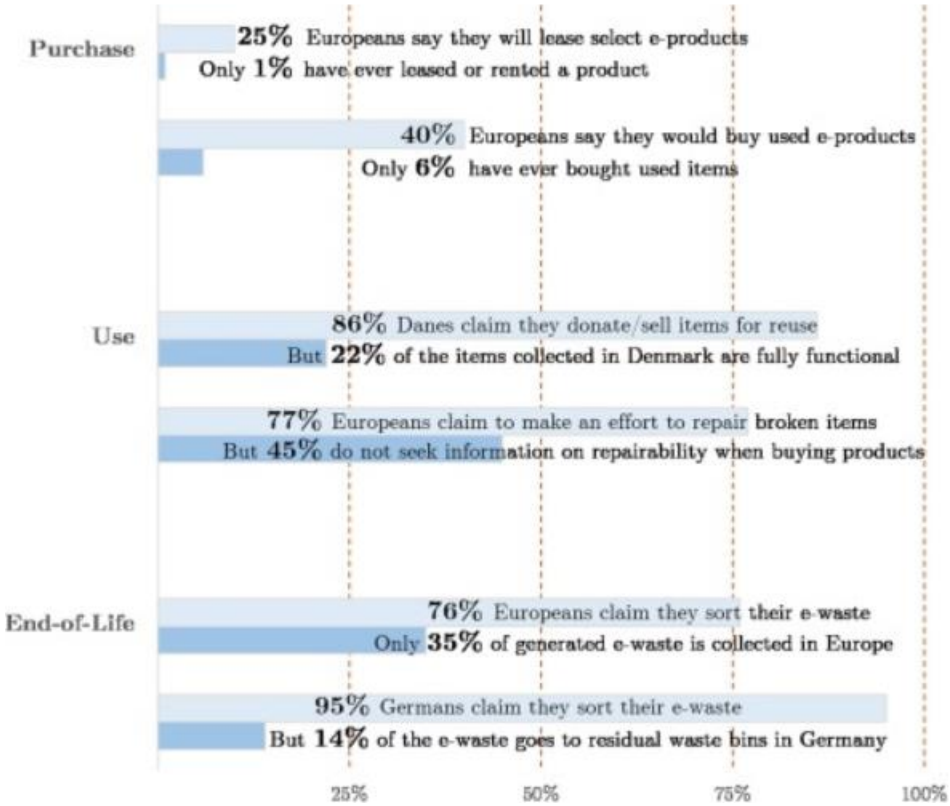
The survey then tries to delve into the CE-related consumption models of the users. Tentative definitions of CE given by some respondents include the idea of 'keeping products, materials and their highest level of value as long as possible … through reuse, remanufacturing, recycling and servitisation".[38]Some others mention the 'reduction [or] the elimination of waste where waste becomes resources and is efficiently used and transformed into products'.

This seems in line with recent studies, such as the latest "Behavioral study on consumers' engagement in the circular economy" by the European Commission (EC, 2018), where consumers declared to be generally willing to engage in CE practices, even though the actual engagement still remains rather low.

According to Parajuly, the majority of Europeans are aware of the environmental issues linked to our consumption models, and the importance of effective use of resources (European Union, 2014). Many of them also claim to participate in waste sorting, and to be willing to try reused items or alternative business models such as leasing (Cerulli-Harms et al., 2018). The practices however, do not reflect the claims made by the people. Some examples of the gap between people's claims and their actions during purchase, use and EoL of e-products are offered in Fig. 1. These examples are based on limited available data on consumer behavior and not all of them may be directly comparable to reflect the gaps, nevertheless, they offer a useful insight. For example, at the product EoL, 76 % of Europeans claim that they sort their e-waste but only 35 % of the generated e-waste is collected under official collection systems in the EU. It implies that part of the sorted e-waste is either stockpiled at homes or collected through unofficial channels. Moreover, these gaps are the outcome not only of consumer choices, but also of available e-waste disposal options and collection systems that are often beyond consumers' control.

[38] For manufacturers, servitisation is the process of developing capabilities to provide services and solutions that supplement traditional product offerings, and provide additional revenue streams.

Figure 31: Knowing vs. Doing. Source: Parajuly et al. 2020



Approximately 2/3 of the consumers surveyed by the EC declared to ‘repair products’ (64%). Repairing products is also one of the top three consumption models declared by PolyCE survey respondents, which include: ‘sorting waste’ (93.75%); ‘purchasing products only when absolutely necessary’ (71.09%); ‘repairing owned products, rather than buying new ones’ (67.97%). According to the EC study, however, “repair decisions are easily disrupted if arranging repair requires effort. These findings indicate that there is a potential to close the gap between consumers’ willingness to engage and their actual engagement”.

Looking more specifically at consumption habits – 6 out of 10 respondents to the PolyCE survey declared that they already rented a tech product, including tools, household devices but also cars.

Even though more than half (56.52%) of the respondents were not aware of such a service (rental), 82% of them were positive about the possibility of renting tech products instead of buying them, and mainly for large household appliances (81.32%), consumer electronics (69.23%) and smaller households appliances (48.35%).

However, when broadening the sample as in the EC 2018 survey, up to 90% of respondents said they have no experience at all in renting, leasing or buying second hand products.

One of the main barriers in this regard is the fact that consumers wish to own their products, and they tend to prefer new/unused products. Driver factors, instead, are mixed and include convenience, possibility to test the product, the chance of reusing the product after use or budget consideration. In general, there seems to be a sizable market potential for business models offering leasing products.

Another factor that may act as a barrier is related to the uncertainty about the quality of second hand products: 14-21% of respondents (EC, 2018) viewed purchasing a new product as better value for money – no matter the possible economic convenience.

Additionally, when it comes to the disadvantages of the sharing economy, the 2018 Eurobarometer survey (DG COMM, 2018) notes that "just under half (49%) see lack of clarity about who is responsible in the event of a problem as the biggest disadvantage. More than one third also mention misleading ratings and reviews from other users (38%), misuse of personal data (37%) and less trust in the providers of services (34%). The least mentioned disadvantages are the fact that services offered are not as expected (24%) and problems with online booking process or payments (22%).

The particular concept of 'product as a service' (CEPS, 2018) (i.e. practices of leasing, renting, pay-per-use or performance-based business models) actually challenges the traditional business approach of selling tangible products, and it has been suggested how this model could bring forward several environmental benefits, including the fact that companies owning the products are motivated to repair and maintain them for a longer period (Accenture, 2014). Benefits, of course, can also derive from the adoption of this model by consumers, even though some other factors can influence their efficacy, such as the level of care by consumers in using products that they do not own.

There is a growing tendency towards a process of 'dematerialization', which is taking place in several aspects of people's lives (PACE, 2019, p.17 et seq.), and includes examples of electronics as a service. "Current leasing and rental models, with monthly contracts for smartphones and even some televisions, allow global consumers to access the latest technology, particularly products with short lifespans and without high up-front costs. Access to innovation and upgrades continues unabated, while barriers to usership have also lowered. With this new ownership model, the manufacturer has an incentive to ensure that all the resources are used optimally over a device's lifecycle. This includes when it is time to be reused by another consumer or recycled. For this to work, however, it is vital that products are kept as services until their last use, or they risk being sold and falling into the informal sector".

There is as well an incentive to keep value in products, extend the life of e-devices, repair them when necessary and reduce the impact of e-products and e-waste on the environment. "[T]he business model shifts to one of an ongoing service, and the subscription economy. This builds a much closer and stronger customer relationship".

From the results of the EC behavioural study (2018), "[i]nterest in product durability and reparability was generally higher for large and expensive products (e.g. white goods), and slightly lower for fashion items (e.g. clothes, smartphones). For fashion products there was however a higher willingness to buy second hand (clothes, smartphones), or to rent or lease such products (smartphones)".

In general, one of the reasons for the low engagement in CE practices "could be that consumers lack information regarding product durability and reparability as well as the lack of sufficiently developed markets (e.g. for second hand products, renting, leasing or sharing services etc.).

Looking at the main purchasing choices of consumers, in fact, the participants to the PolyCE survey declared that the main influencing factors are that the product is 'long-lasting', 'repairable', 'green' (eg. with eco-labels), while the 'possibility to borrow under a service agreement' does not seem to be a priority so far.

A behavioural experiment was conducted in the framework of the above mentioned EC study, involving a repair experiment and a purchasing experiment. In the repair experiment, respondents needed to choose to repair, or replace a broken product. If they decided to replace, they could choose between a second hand or brand new product. In the purchasing experiment, respondents needed to choose to purchase one product from a selection of six presented on a simulated e-commerce platform. In the behavioural experiment the provision of such information was found to be highly effective at shifting purchasing decisions towards products with greater durability and reparability" (EC, 2018).

A similar social experiment was carried out within the project PolyCE, in the efforts of its overall aim of significantly reducing the use of virgin plastics and enhancing the use of recycled plastics in new electronic applications. In the social experiment, consumers were faced with a purchasing choice situation and they had to select an appliance based on their needs and priorities: durability, design, upgrade possibilities. Two vacuum cleaners with similar features were presented, one with recycled plastics and one without. As a result, none of the interviewee could see a difference in terms of material quality or design, and all of them chose the item containing recycled plastics, considering it was a more sustainable choice. The participants recommended the producers to use more recycled plastics in their products and to make the composition appear clearer to facilitate the consumers' choice[39].

In line with the general results of the social experiment, half of the PolyCE survey respondents were not aware if they'd ever bought a tech product containing recycled plastics, highlighting a general lack of knowledge or awareness in this regard.

85% of consumers who did buy tech products containing recycled plastics did not notice any issue in terms of quality, performance or appearance. Indeed, being aware of the positive effects on the environment and human health, 95.8% of the respondents confirmed they would consider buying a tech product if it was clearly labelled it contains recycled plastics.

The main reasons listed by respondents for either avoiding or choosing recycled plastics in tech products are summarized in Table 11.

[39] See the social experiment video on the project website: https://www.polyce-project.eu/

Table 12: Reasoning behind preference towards and refection of PCR plastics in EEE products. Source: PolyCE survey 2019, UNU elaborations

AVOIDING RECYCLED PLASTICS IN TECH PRODUCTS	CHOOSING RECYCLED PLASTICS IN TECH PRODUCTS
Quality (recycling associated to waste)	Environmental awareness and commitment
Low availability of products	Environmental impact and promoting transition to circularity
Lack of awareness	'Green' choice
Safety concerns	Price / Quality not changing
Expected life-span	Creating demand and value in the recycling system
Aesthetic factors	Positive social impact

Focusing on the e-waste treatment, 97% of respondents to the PolyCE survey agree with the fact that an 'improper treatment of e-waste has a negative impact on the environment and human health'.

More specifically, on 'tech products' and the actions taken by consumers with old ones no longer used, 68.22% of the respondents replied that they 'discarded them in a dedicated e-waste collection point', while 48% 'kept the products at home'. The main reason for discarding old tech products is that 'it is the right thing to do, for myself and the planet' (93%), even though sometimes the choice can be simply related to logistic reasons such as 'organizing/decluttering'. Only 4.65% consider the fact of receiving a reward or discount as a reason for correctly recycling e-waste.

Instead, the main reasons for 'not discarding' old tech products are mainly related to the lack of collecting facilities, the lack of knowledge on appropriate methods, and also concerns regarding the privacy of personal data contained in devices such as mobiles, laptops etc.

ANNEX II

"Going Circular! A pledge for recycled plastics in new EEE applications as strategic company choice"

Refer to PowerPoint file.

List of tables and figures

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Note: all websites were last accessed on 25/05/2020.

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