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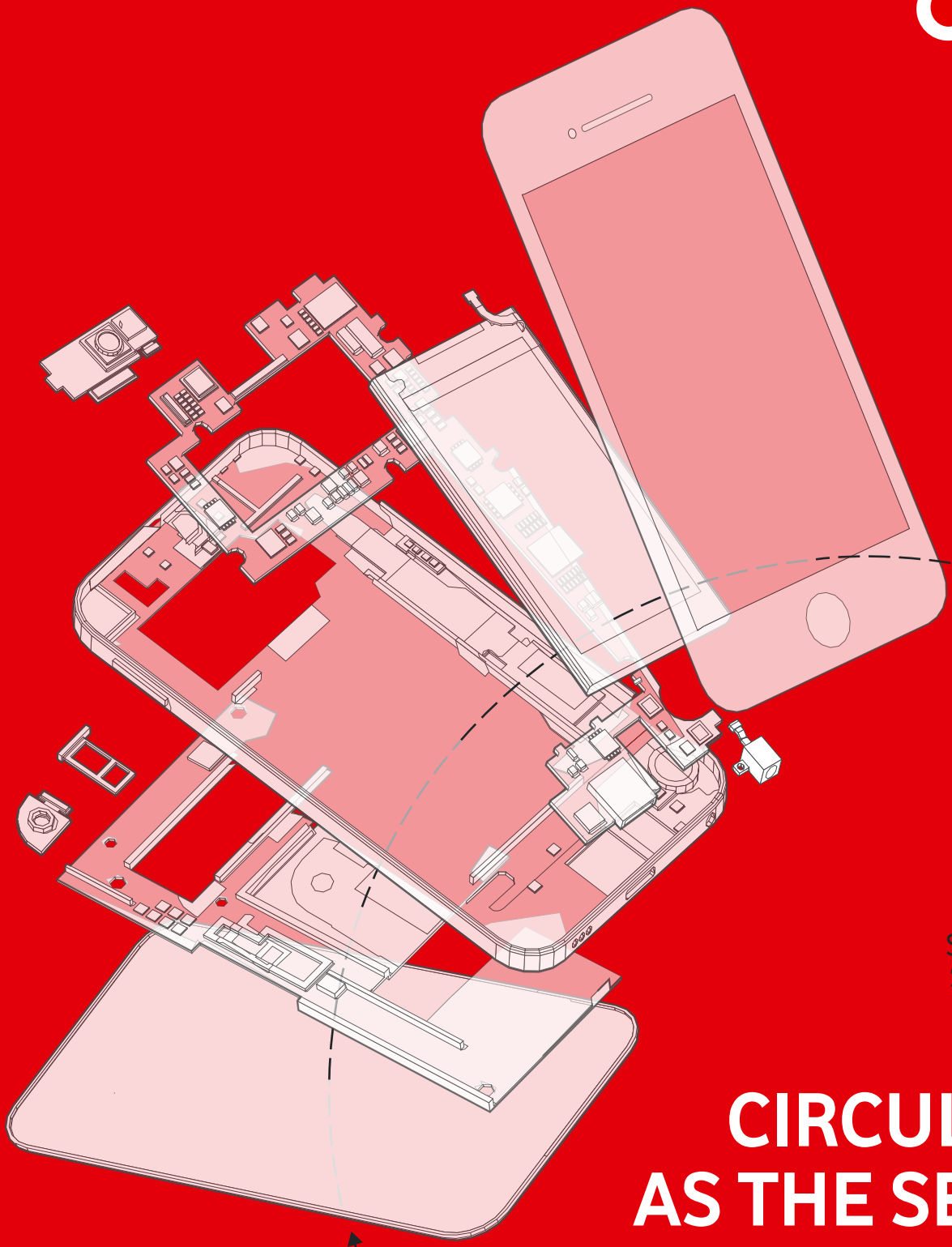

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CIRCULARITY AS THE SERVICE

The future of the smartphone: Paths to the circular economy

Wuppertal Institut

Contents

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Summary

Our core message: Sustainable smartphone usage must become central to the consumer experience

It is no longer possible to imagine a world without smartphones, which have become critical companions in our everyday lives. They play a central role in our digital communications and are our most important access point to the digital world. Currently, around 20 million new devices are sold each year in Germany. That, though, is linked to significant environmental effects, particularly from the greenhouse gases emitted and the resources consumed during the smartphone production phase.

Through a circular economy (CE) with a focus on extending the amount of time devices are used, the resources involved in production could be better utilised and total resource consumption reduced. As such, the goal is that of extending usage spans from the current average of 2.5 years to an optimal period of five to seven years – which would reduce greenhouse gas emissions by around 50 %. This potential of extended smartphone usage, however, is not currently being exploited. The reasons that consumers cease using functional devices vary from case to case, but for all target groups, it is possible to identify specific approaches for extending use.

The reorientation in smartphone usage requires a change of perspective: Instead of focusing on selling new devices, the primary goal should be that of extending the life- and usage spans of smartphones. On the one hand, this requires a shift in our perception and our consumption behaviours as users, including a stronger acceptance of used and repaired devices. But to make sustainable consumption attractive and suitable for our everyday lives, additional support is necessary from all actors in the smartphone ecosystem. Value creation surrounding the smartphone must change, offers and services must be made more easily accessible, and the sustainable use of smartphones must become central to the consumer experience.

We need Circularity as the Service.

A more sustainable usage of smartphones that conserves resources can ultimately only be achieved through the summation of contributions made by all stakeholders and the integration of various approaches. Everyone involved in the system can already contribute to the transformation today – and all are called upon.

Producers and software providers can gear their products toward longevity and reparability in terms of design, functionality and lifespan and enable easy recycling once that lifespan ends.

R-Actors, such as repair services and refurbishers, can offer easily accessible services, professionalise their offerings and boost trust in used devices through certificates and seals of quality.

Retailers, distributors and telecommunication companies can make sustainable offers and options available and visible (through partnerships with R-actors), they must provide opportunities for easy returns, and they must reduce marketing strategies geared exclusively toward new devices (such as linking them to mobile devices).

Policymakers can establish additional incentives for the development and implementation of circular designs and continuously improve the policy conditions for circular business models.

It is time to act – these opportunities can and must be taken advantage of.

THE TASK

MAKING SMART-PHONES MORE SUSTAINABLE

1

Digitalisation shapes our modern lives. We now use digital technologies and services in all aspects of our lives: at work, at home, in our free time and for communicating with colleagues, friends and family. The smartphone has been a major driver of this development. From the widely mocked, bulky "handheld" devices that emerged in the late 1980s, they have now become elegant multipurpose devices with virtually unlimited possibilities – to the point that it has become difficult to imagine life without them. At a time of rapid climate change, seemingly unchecked resource consumption and the endangerment of vital species diversity on our planet, this development raises an important question: How can the smartphone, which we hold in our hands every single day, be designed and used more sustainably?

That is what this discussion paper will address.

Its goal is to raise awareness of the ecological issues involved and the concurrent need for action when it comes to the current smartphone system. The focus will be on resource consumption related to the production and use of smartphones – and on possible measures and related strategies for more efficient and, especially, extended use of those resources.

It seeks to provide direction toward the development of a target for more sustainable and circular smartphone usage.

It aims to develop and enable action through the identification of circular economy approaches aimed at future-oriented, resource-conserving business models and services – which offer opportunities for all stakeholders in the smartphone ecosystem.

This discussion paper offers an overview of future-oriented and resource-preserving circular economy approaches, with smartphone use patterns in Germany serving as a starting point. It thus lays the groundwork for the implementation of concrete concepts. The goal was to complement current approaches and lines of discussion and expand on them with a comprehensive and system-oriented look at the entire smartphone environment. This allows for an examination of the interactions between the various interest groups involved in the entire lifecycle of the devices – which is the foundation of the discussion regarding possible action and concrete approaches for more climate and resource protection when it comes to smartphones.

Why are we focusing on smartphones?

As multifunctional end devices, smartphones have become the central interface for digital communication and our most important entry point into the digital world. The omnipresence of smartphones can be seen in the constantly climbing usage statistics in our work and private lives. According to Bitkom, the expansion of smartphones reached a new high in 2022, with 83 % of Germans over the age of 16 using a smartphone and 90 % of those users unable to imagine life without one.[1] One-third even use more than one device[2], such that the question is no longer whether a smartphone is used, but how many and for what purposes.

Through this use behaviour, the economic value of the entire smartphone market in Germany is growing – by 1.3 % in 2024 over the previous year to a volume of 38.9 billion euros.[3] The primary source of value creation has increasingly shifted from hardware to software and services. Even in an almost completely satiated market like Germany's, in which only very few consumers don't use a smartphone and device sales are no longer constantly climbing, the number of new devices remains high due to exchange cycles and replacement purchases. With a penetration rate of 90 %, Germany is among the smartphone markets with a high saturation level[4], and yet in the year 2023, around 20 million smartphones were sold in Germany alone.[5]

Because the average service life of smartphones is, at 2.5 years[6], still quite brief, it can be assumed that the status quo will continue to be a high number of new devices – and thus, a correspondingly consequential environmental impact – even in saturated markets. This is partly due to the short product cycles of manufacturers, with a constant stream of new models, in addition to the established sales models used by telecommunications companies (telcos), in which discounted smartphones are used as marketing incentives for mobile phone contracts (so-called bundles). In addition to the many active smartphones, around 210 million smartphones are currently lying unused in German households.[7]

83 %
of Germans over the age of 16 use a smartphone

90 %
of users cannot imagine life without a smartphone

33 %
of users have more than one smartphone

1 Bitkom e. V. (2022a). Smartphone market grows to 36.8 billion euros. https://www.bitkom.org/Presse/Presseinformation/Smartphone-Markt-waechst-368-Milliarden-Euro

2 Bitkom e. V. (2021). Smartphone market: Development and trends. https://www.bitkom.org/sites/default/files/2021-02/bitkom-presse-konferenz-smartphone-markt-25-02-2021_0.pdf

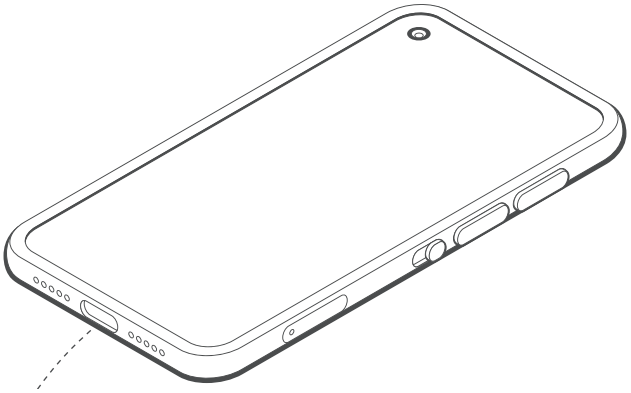
3 Bitkom e. V. (2024) Smartphone market grows to 38.9 billion euros. https://www.bitkom.org/Presse/Presseinformation/Markt-Smartphones-waechst

4 German Federal Statistical Office (2022). Equipment with consumer durables - data from the Current Economic Accounts (CEA) on the equipment of private households with information technology. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/Ausstattung-Gebrauchsgueter/Tabellen/a-infotechnik-d-lwr.html

5 Bitkom e.V. (2024). Smartphone market grows to 38.9 billion euros. https://www.bitkom.org/Presse/Presseinformation/Markt-Smartphones-waechst

6 ibid.

7 Bitkom e. V. (2022b). Smartphones, tablets, laptops: Almost 300 million old devices in German households. https://www.bitkom.org/Presse/Presseinformation/Smartphones-Tablets-Laptops-300-Mio-Alt-Geraete-deutschen-Haushalten



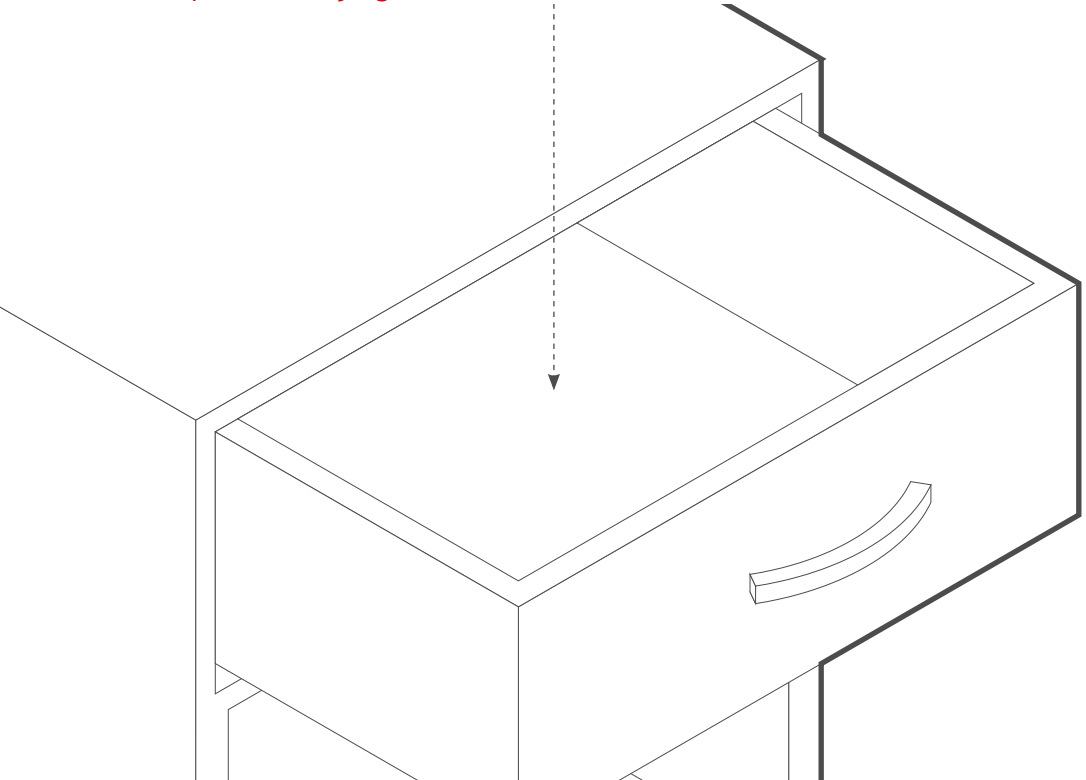
20,000,000

new smartphones were sold in Germany in 2023

Smartphones are used
for an average of
2.5 YEARS

210,000,000

smartphones are lying unused in German households



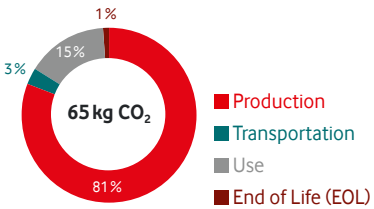
How can we reduce the ecological footprint of smartphones?

Currently, every person in Germany is responsible for an annual average of around 10 tonnes of CO_2 equivalent, with information and communications technology making up around 8 % of that total[8], at 849 kilograms per person. In comparison to other areas, such as living and mobility, the share appears to be relatively small. But a current forecast by the Federal Environment Office[9] makes clear that barring a situation such as an economic crisis, Germany will fall significantly short of its emissions reduction targets by 2030 and that additional, ambitious measures are necessary in all sectors, and not just in transportation.[10] To achieve the goal of climate neutrality by 2045, it is thus necessary to reduce the sum of average emissions in all areas by more than 90 % to under one tonne of CO_2 equivalent per person and year.[11]

That makes it clear that emissions related to information and communications technologies must be drastically reduced. Because it is no longer possible to imagine life without digital technologies, smartphones first and foremost, the goal cannot be that of simply eliminating smartphones. Rather, we must reduce the ecological footprint of smartphones as much as possible while maintaining their user-oriented value and effectiveness. A consideration of smartphone solutions that conserve resources while still being user-oriented can thus serve as a best-use case and point the way to the future for other digital information and communication technologies.

Interestingly, in addition to the mobile network's energy consumption as it pertains to data transmission, the environmental impact of smartphones is primarily a function of greenhouse gas emissions and resource consumption during production.[12] For the Apple iPhone 14 Pro, for example, calculations show a carbon footprint of 65 kilograms per lifecycle, with production accounting for by far the largest share (81 %).[13] On top of that come the ecological effects of the extraction and processing of the many different raw materials required for the production of electronic components (see info box on the right).

The CO_2 consumption of an iPhone 14 Pro



Valuable resources and rare earths in smartphones

Smartphones contain a variety of valuable raw materials. These include metals such as copper, precious metals like gold and tantalum, and rare earth metals such as neodymium. Although they are only used in small quantities in the electronic components, they are essential. The recycling of electronic waste currently specialises in metals such as copper, silver and gold, while other metals and rare earths are almost never recovered. A comprehensive overview of the current situation regarding metals used in smartphones and their recycling is provided by the German Mineral Resources Agency.

8 Janson (2022). The CO2 footprint of our digital life. https://de.statista.com/infografik/27216/co2-emissionen-durch-information-stechnik-in-deutschland-pro-kopf/; based on Gröger (2020). Digital CO2 footprint. Data collection to estimate manufacturing costs, energy consumption and usage of digital end devices and services. On behalf of the German Federation for the Environment and Nature Conservation (BUND e.V.).

9 Schultz et al. (2024). Greenhouse gas projections 2024 – results summary. Umweltbundesamt. www.umweltbundesamt.de/sites/default/files/medien/11740/publikationen/thg-projektionen_2024_ergebnisse_kompakt.pdf

10 Fischedick & Samadi (2024). Estimated development of greenhouse gas emissions in Germany in 2023 (focus on energy and industrial sectors). Wuppertal Institut. https://wupperinst.org/a/wi/a/s/ad/8513

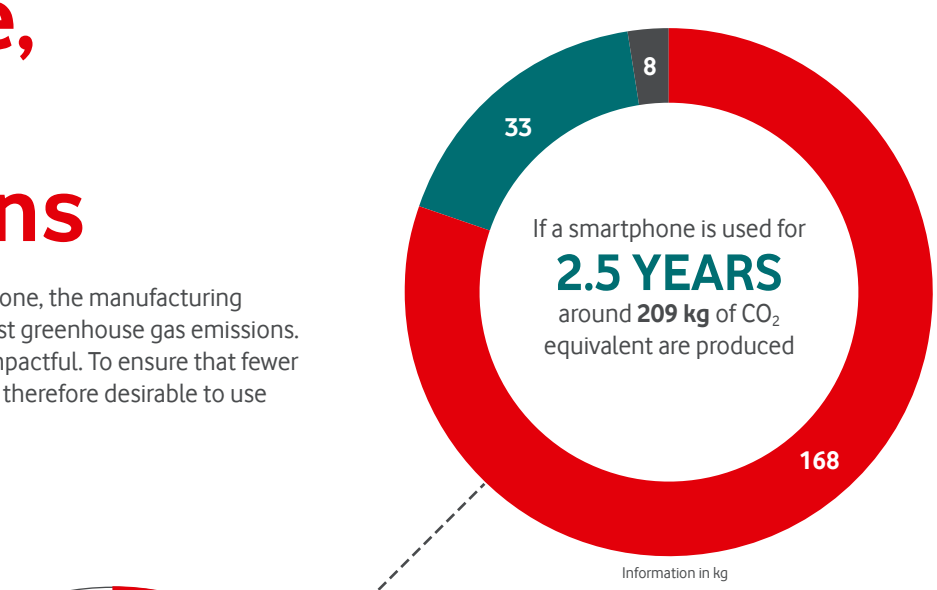
11 Umweltbundesamt (2021). How high are average per-capita greenhouse gas emissions in Germany? https://www.umweltbundesamt.de/service/uba-fragen/wie-hoch-sind-die-treibhausgasemissionen-pro-person

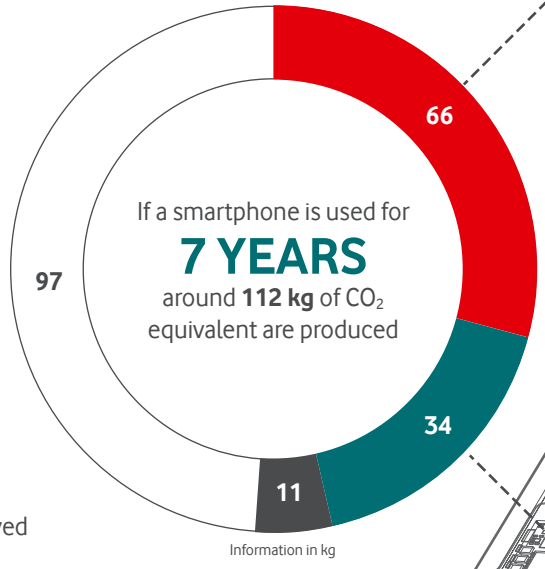
12 Umweltbundesamt (2023). From purchase to disposal: sustainable use of smartphones and tablets. https://www.umweltbundesamt.de/umwelttipps-fuer-den-alltag/elektrogeraete/smartphones-tablets#gewusst-wie

13 Apple (2022). iPhone 14 Pro Product Environment Report. https://www.apple.com/environment/pdf/products/iphone/iPhone_14_Pro_PER_Sept2022.pdf

Longer lifecycle, lower emissions

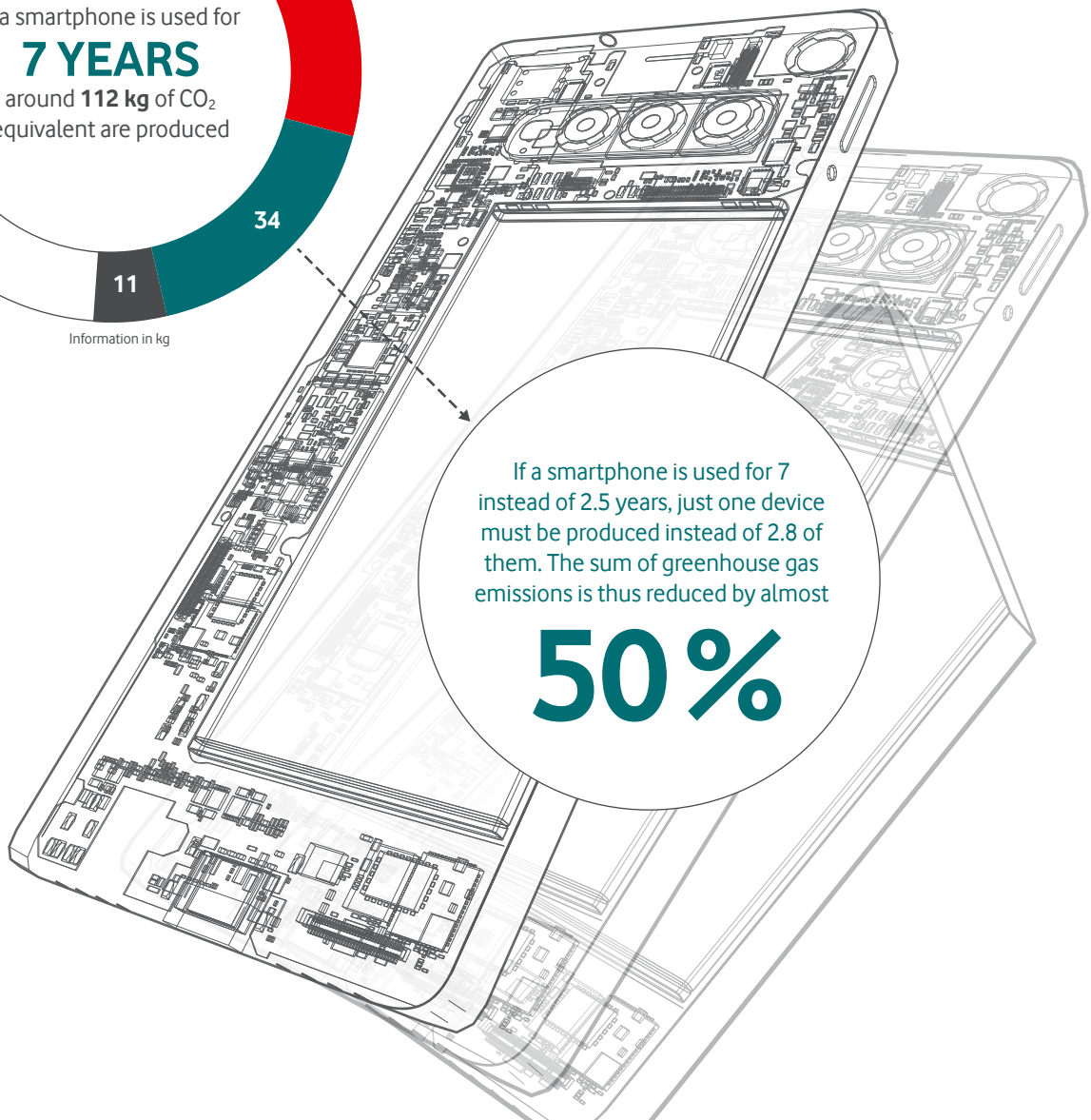
In the lifecycle of a smartphone, the manufacturing process produces by far the most greenhouse gas emissions. Repair and use are much less impactful. To ensure that fewer smartphones are produced, it is therefore desirable to use them for longer.





- Production
- Use
- Repair

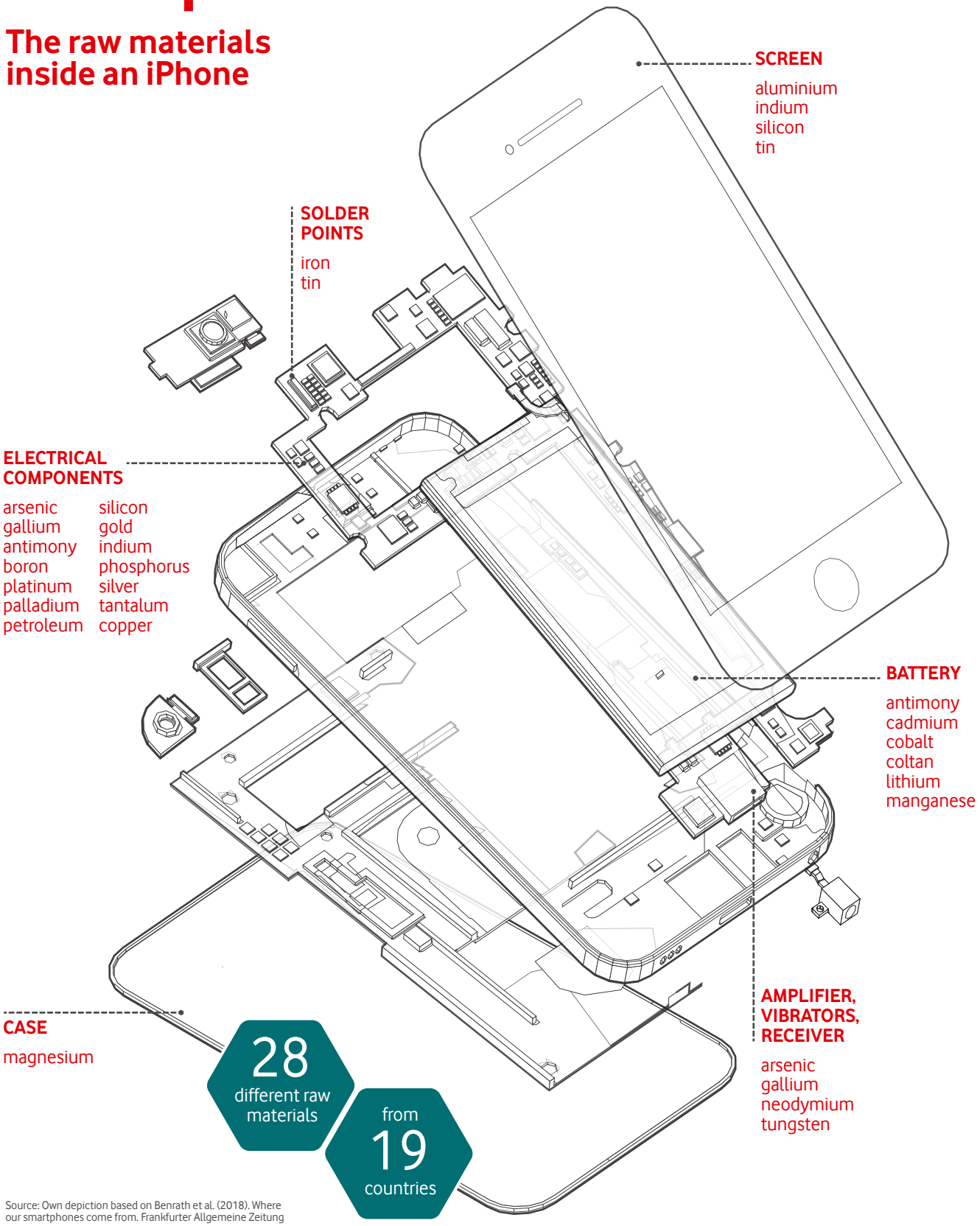
☐ Emissions saved



Source: Rüdenauer, I., & Prakash (2020). Economic and ecological effects of extending the use of electrical and electronic devices. Ökoinstitut e. V.

What is in a smartphone?

The raw materials inside an iPhone



Source: Own depiction based on Benrath et al. (2018). Where our smartphones come from. Frankfurter Allgemeine Zeitung

With this in mind, the goal must be that of using the exploited raw materials and the smartphones already produced for as long as possible. This is all the more important because under current conditions, the contribution of electronics recycling, to name one example, remains inadequate when it comes to climate and resource protection. Too few old devices are collected and returned, and there is a lack of technically and economically viable technologies to achieve closed recycling loops for all raw materials.

In short: The outcome must be a reduced need for the production of new smartphones and a longer use period for existing devices. This could have a noticeable effect: By extending the useful life of a smartphone from the current average of 2.5 years to 7 years, for example, the greenhouse gas potential of a smartphone across its entire lifecycle can be reduced by almost half.[14] The purchase of a used or refurbish smartphone can lead to an 82 % savings on CO_2 emissions relative to the purchase of a new device.[15]

The outcome must be a reduced need for the production of new smartphones and a longer use period for existing devices.

This could have a noticeable effect.

The ecological effects of smartphone production and use sketched out above are now being more intensively discussed. Scientific studies and analyses are increasingly focusing on lifecycle assessments, climate effects and resource consumption related to smartphones and digital technologies in general. There is still a considerable need for research, however, as data remains relatively limited. In particular, the diverse ecological effects in international supply chains remain poorly understood.

The assessment of the ecological effects of the smartphone also seems to be making inroads into the market as well, as more and more commercial offers, business models and new players are addressing specific aspects of climate and resource protection. Issues associated with new circular economy business models, extended use and sustainable product-service systems are being discussed more intensively – but there are still relatively few empirically validated findings, while concepts that can be easily introduced and scaled also remain rare.

The smartphone system must therefore be further developed, and the resources involved must be used more efficiently. That is where this discussion paper comes in.

14 Rüdenauer & Prakash (2020). Economic and ecological effects of extended usage of electrical and electronic devices. Ökoinstitut e. V.
15 www.refurbed.de/a/pressrelease-refurbed-fraunhofer/

2

THE CHALLENGE

EXPLOITING USAGE POTENTIALS

The message is clear: Smartphone usage is the starting point. But how are smartphones actually used, and where does the potential lie for extending usage? Here, some data and facts from current research.

How are smartphones currently being used?

The findings right from the start: The potential offered by extending smartphone usage is significant because the average usage time of the devices is relatively brief, at two to three years – and far below the possibilities offered by an actual, designed and optimal lifespan for the devices. Here, a brief explanation of terms:

Actual lifespan: 3–5 years

Actual lifespan describes the period of time during which a smartphone is useable. Because of hardware limitations, it is currently estimated to be between three and five years.[16] Frequently, though, the amount of time individuals use specific devices is much shorter, since many smartphones are replaced much earlier and end up in the trash or in a drawer, even though they are still useable.

Designed lifespan: 4–7 years

Designed lifespan refers to the maximum lifespan envisioned by the manufacturers, which is influenced by design and after-sales service, such as security updates. In terms of security updates, the secure lifespan foreseen by the manufacturer is currently four years for Android, six years for Apple devices[17] and up to seven years for the newest Samsung devices.

Optimal lifespan: 5–7 years

Optimal lifespan from both an ecological point of view and from the perspective of cost-effectiveness for users is seven years.[18] Users would also like to see a longer lifespan of 5.2 years.[19] As such, this paper assumes an optimal lifespan from an ecological, social and economic perspective of five to seven years.

16 Everphone (o. J.). What is the average smartphone lifespan? https://everphone.com/en/blog/smartphone-lifespan/

17 Nagel (2023). Sustainable use of smartphones and tablets. Challenges and solutions. Everphone. https://everphone.com/de/whitepapers/mobile-device-sustainabilty-report/

18 Rüdenauer & Prakash (2020). Economic and ecological effects of extended usage of electrical and electronic devices. Ökoinstitut e. V.

19 Wieser, Tröger & Hübner (2015). Usage span and obsolescence of consumer goods in the age of acceleration. Kammer für Arbeiter und Angestellte für Wien.

Reasons for shortened usage time – and what can be done about it.

Three main categories are helpful for understanding why a smartphone is no longer used: objective obsolescence, functional obsolescence and subjective obsolescence.[20] Obsolescence broadly describes the state in which a device is no longer used or no longer can be used.

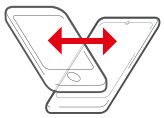
Objective obsolescence

The term objective obsolescence describes the end of a smartphone's actual lifespan. Use of the device comes to an end when it is no longer technically functional and cannot be repaired. Potential causes include material wear or the incompatibility of software and hardware. Objective obsolescence is primarily influenced by product design and market developments, since they have a direct effect on smartphone usage time. As such, an initial focus when it comes to delaying objective obsolescence should be on extending the smartphone's technical lifespan through quality manufacturing and product design – a strategy known as longevity by design.

Functional obsolescence

If a device is not defective and is still essentially functional, but its use is restricted and inconvenient due to slower operations, outdated technology and reduced battery life – or if the device is only temporarily non-functional and can actually be repaired – it is described as being functionally obsolete. Delaying functional obsolescence requires approaches that prevent the loss of smartphone functionality and promote maximal useability. That includes continual security and software updates that are compatible with the hardware along with affordable repair offerings. Manufacturers and market developments play an important role here as well, since they establish the conditions for individual user behaviour.

Subjective obsolescence



Subjective obsolescence refers to instances in which a device is no longer used and is replaced despite not having reached the end of its lifespan. It describes a functional smartphone that is no longer used because the user regards the product as being obsolete or unattractive – through social pressures, for example, the release of new (flagship) models or marketing campaigns.

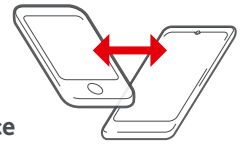
Depending on the specific consumer group targeted, strategies aimed at delaying subjective obsolescence include awareness campaigns that boost more sustainable individual usage behaviour (such as repair incentives) and approaches that extend the usage spans of devices on the whole, because once one person ceases using a specific device, it can still be used by another person or organisation.

20 Bachér, Dams & Duhoux (2020). Electronic products and obsolescence in a circular economy. European Environment Agency. www.eionet.europa.eu/etcs/etc-wmge/products/etc-wmge-reports/electronics-and-obsolescence-in-a-circular-economy; Proske et al. (2016). Obsolescence of Electronics – the Example of Smartphones. Electronics Goes Green 2016+(EGG), IEEE; van den Berge & Thysen (2020). State-of-the-art knowledge on user, market and legal issues related to premature obsolescence. www.prompt-project.eu/wp-content/uploads/2020/07/PROMPT_20200430_State-of-the-art-overview-of-the-user-market-and-legal-aspects.

Strategies for extending smartphone usage

Approaches for specific types of obsolescence

Subjective obsolescence



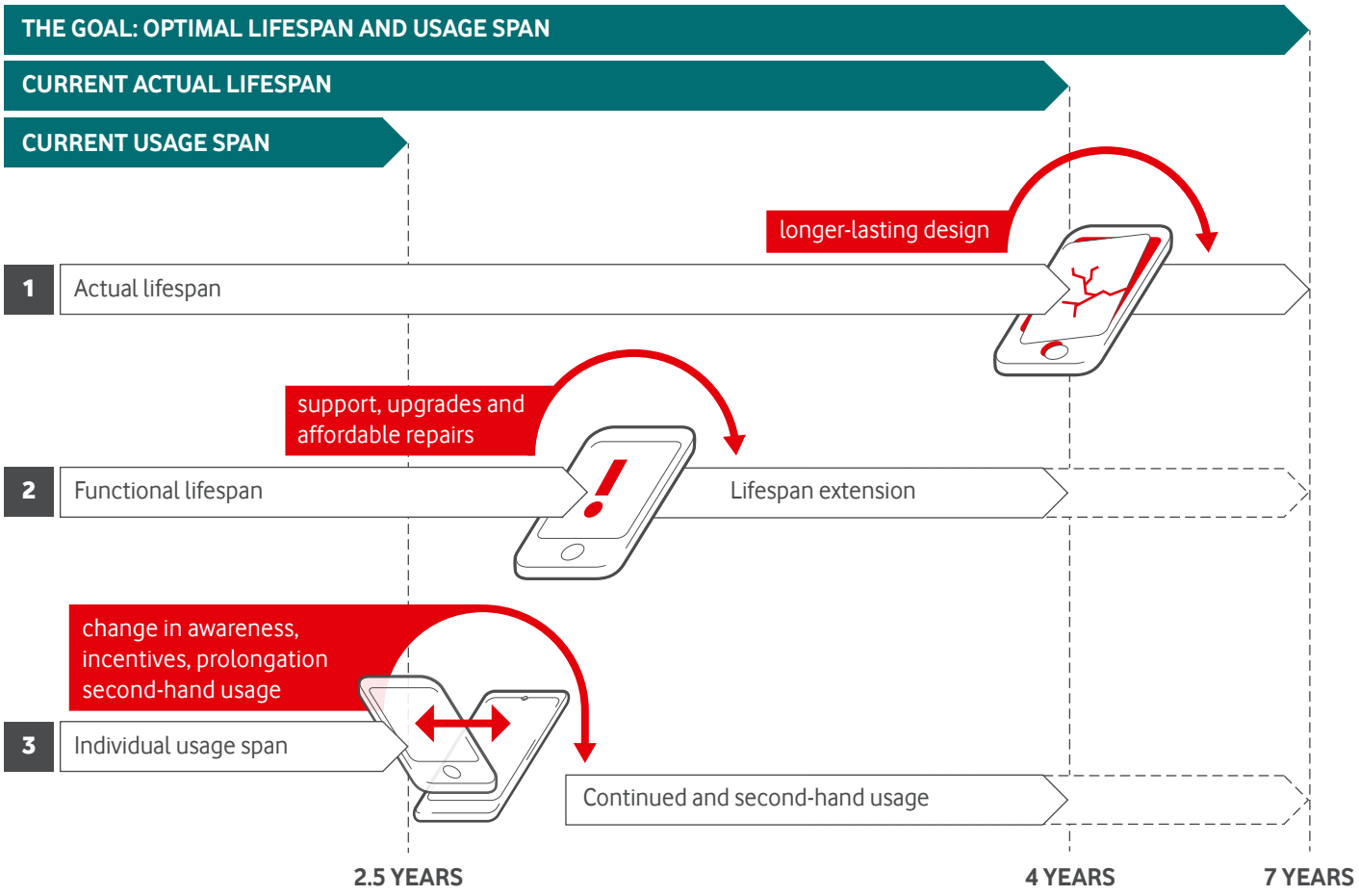
The smartphone is still functional but is seen as being obsolete or unattractive.

Functional obsolescence

The smartphone no longer works, but the problem(s) can be rectified.

Objective obsolescence

The smartphone is no longer functional and can no longer be repaired.



Source: Own illustration based on Everphone (o. J): What is the average lifespan? www.everphone.com/en/blog/smartphone-lifespan/

How are use and obsolescence differentiated in various target groups?

People are different. They have individual needs, convictions and priorities. As a result, there are a number of reasons for why people replace their smartphones and various factors impacting their willingness to take advantage of offers aimed at extending use. As such, approaches and individual offers tailored to specific target groups help exploit the potential for extending usage spans. A look at typical smartphone user profiles reveals differences regarding the reasons for obsolescence.

Long-term and price-sensitive users

Long-term and price-sensitive users continue using their smartphones until the very end of its lifespan – the first group as an expression of their rejection of fast-paced consumerism, the second in an effort to optimise the device's economic potential.

Tech enthusiasts and aesthetes

Tech enthusiasts and aesthetes who expect high performance from their devices, by contrast, are quick to see their smartphones as obsolete and replace devices that are still functional.

Sustainability enthusiasts, pragmatists and business customers

Sustainability enthusiasts, pragmatists and business customers are located between these two extremes. Pragmatists see their smartphones as a tool that must function well and perform the services they need. They only replace their smartphones when that performance is no longer optimal or operation has become suboptimal. It is similar for sustainability enthusiasts, who are characterised by a high level of environmental awareness, but also by a desire for self-realisation and an expression of their identity, with corresponding demands on consumer products. For the diverse, business customer group, functionality and security are top priorities – meaning their justifications for replacing their devices are generally functional in nature and they are likely to replace their smartphones sooner rather than later.

The willingness to take advantage of offers aimed at extending usage – such as repair, extended usage or the purchase of a second-hand device – is likewise varied. Sustainability enthusiasts are particularly interested in used or refurbished smartphones, sustainable manufacturer brands and repair options. But other groups are also open to such offers. Pragmatists and long-term users, for example, are open to refurbished smartphones, and many business customers also use refurbished technological products. Owners of powerful and high-quality smartphone models such as iPhones, many of whom fall into the category of aesthetes who expect high performance from their devices, are increasingly interested in repair options.

Typical use profiles

Smartphone users vary according to their consumption patterns, use behaviours and their reasons for replacing their devices. These differences enable a systematic differentiation of consumers and the identification of typical smartphone user profiles.[21]

Long-term users want to use their smartphones for as long as possible and refuse to see it as a status symbol or as an easily replaceable, disposable product.

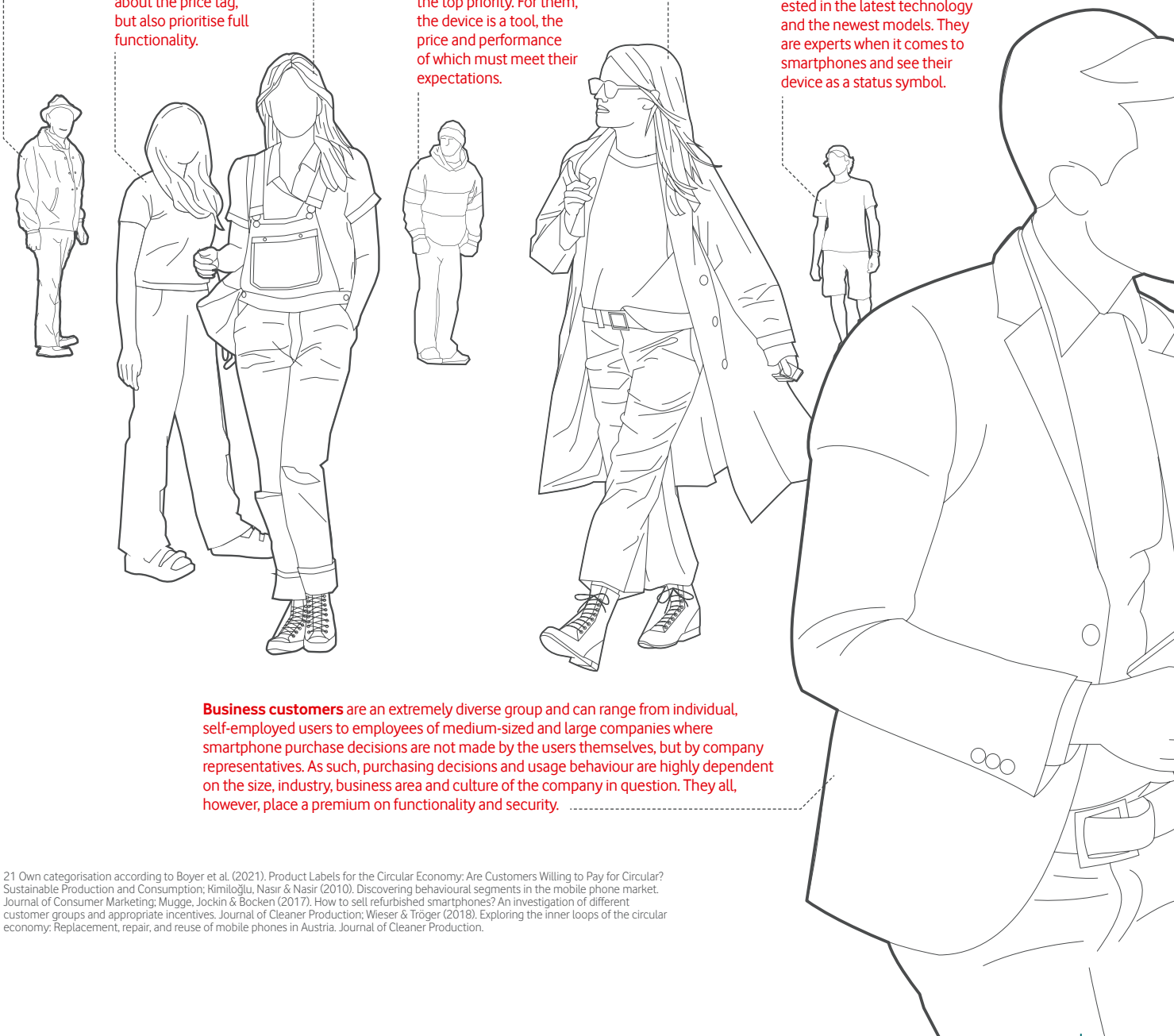
Price-sensitive users are most concerned about the price tag, but also prioritise full functionality.

Sustainability enthusiasts have a strong environmental awareness and express these consumer values through their smartphone use habits.

For **pragmatists**, the quality and functionality of their smartphone is the top priority. For them, the device is a tool, the price and performance of which must meet their expectations.

For **aesthetes** who expect high performance from their devices, smartphones are also status symbols – they use their devices to express their personalities and lifestyles. They don't, however, limit their expectations to the appearance and design of the devices. They must also be high-performance and extremely functional.

Tech enthusiasts are interested in the latest technology and the newest models. They are experts when it comes to smartphones and see their device as a status symbol.



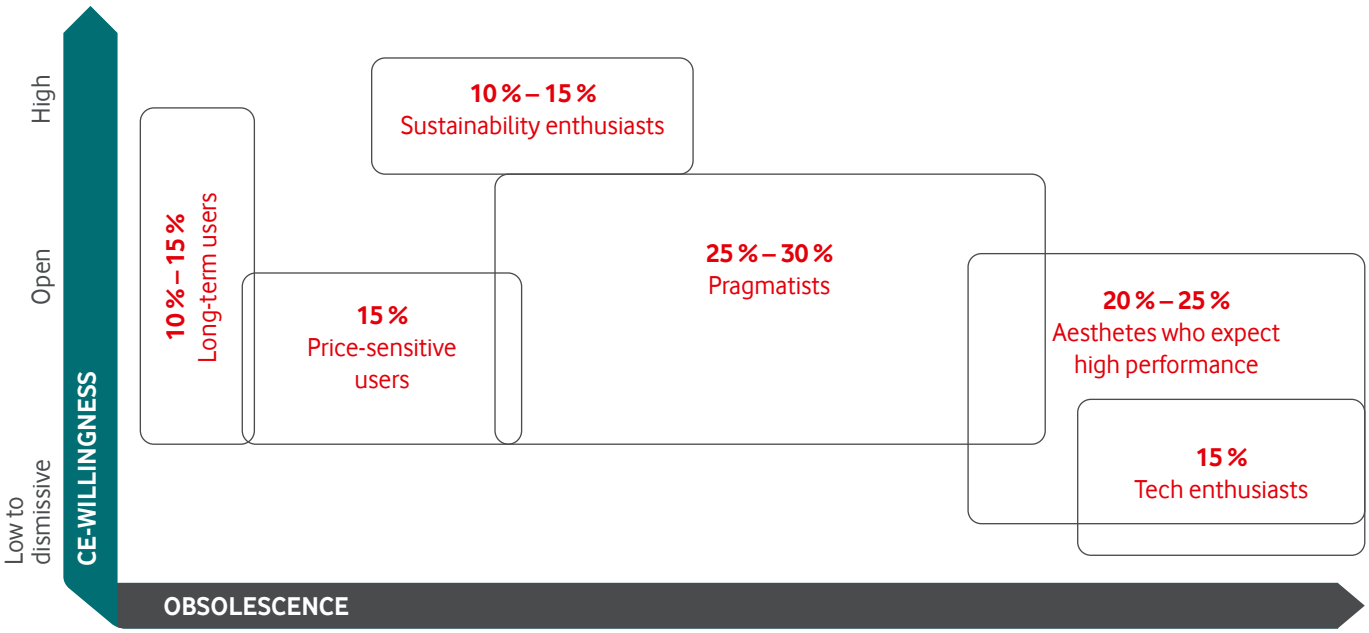
Business customers are an extremely diverse group and can range from individual, self-employed users to employees of medium-sized and large companies where smartphone purchase decisions are not made by the users themselves, but by company representatives. As such, purchasing decisions and usage behaviour are highly dependent on the size, industry, business area and culture of the company in question. They all, however, place a premium on functionality and security.

21 Own categorisation according to Boyer et al. (2021). Product Labels for the Circular Economy: Are Customers Willing to Pay for Circular? Sustainable Production and Consumption; Kimiloğlu, Nasır & Nasir (2010). Discovering behavioural segments in the mobile phone market. Journal of Consumer Marketing; Mugge, Jockin & Bocken (2017). How to sell refurbished smartphones? An investigation of different customer groups and appropriate incentives. Journal of Cleaner Production; Wieser & Tröger (2018). Exploring the inner loops of the circular economy: Replacement, repair, and reuse of mobile phones in Austria. Journal of Cleaner Production.

Individual differences in usage behaviours

Smartphone end users can be divided into six consumer types. These differ significantly when it comes to the reasons for why a smartphone is no longer used (= Obsolescence).

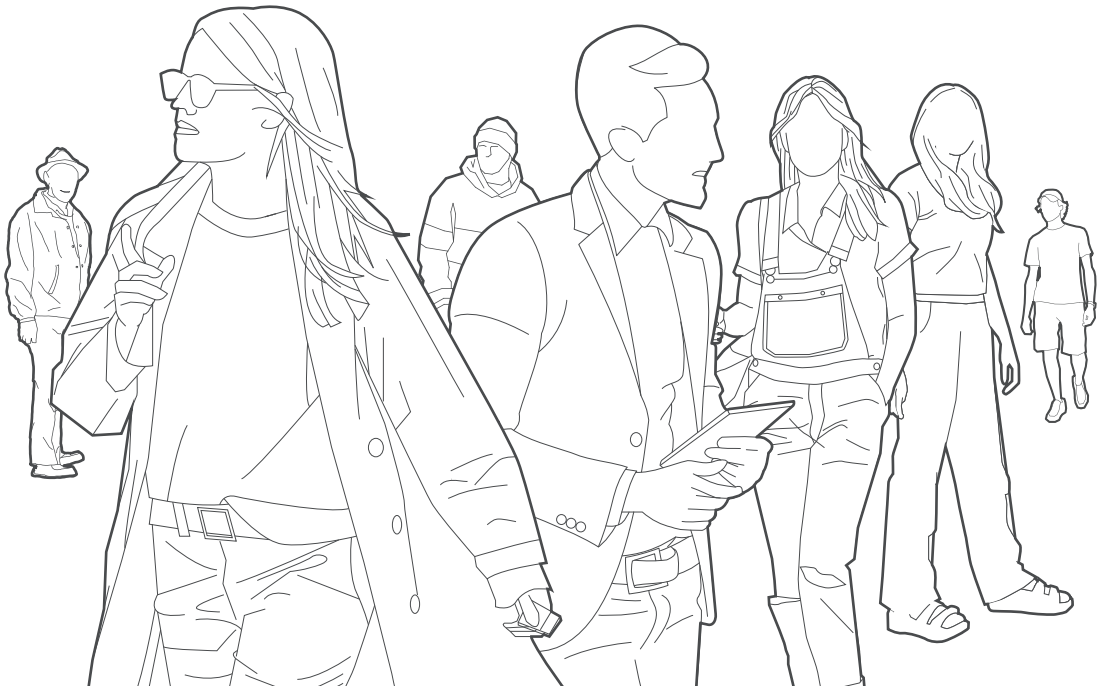
In addition, there are differences when it comes to the willingness to take advantage of offers aimed at extending usage (= CE-willingness). These offers may include repair, continued use and the purchase of used devices.



Objective
The smartphone is no longer functional and can no longer be repaired.

Functional obsolescence
The smartphone no longer works, but the problems can be rectified.

Subjective obsolescence
The smartphone is still functional but is seen as being obsolete or unattractive.



Source: Own illustration based on Boyer et al. (2021); Kimiloğlu, Nasır & Nasır (2010); Mugge, Jockin & Bocken (2017); Wieser & Tröger (2018).

THE FOUNDATION

WHAT WE NEED TO KNOW ABOUT THE ENTIRE SMART-PHONE SYSTEM

3

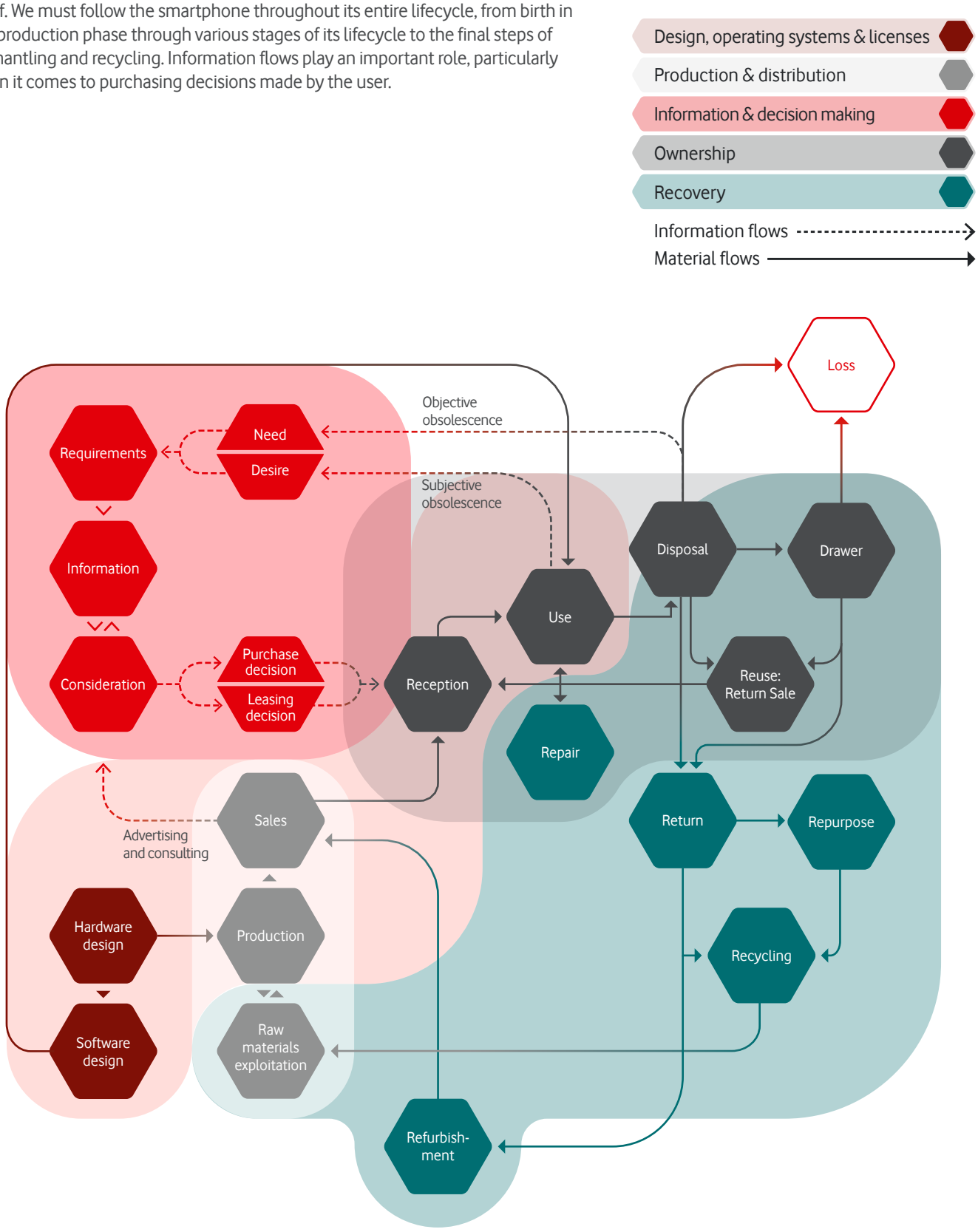
While the spotlight was on the users in the last section, our focus now shifts to the smartphone system in its entirety. To develop solutions for sustainable and resource-efficient smartphone design and for extended usage, it is important to widen the view beyond just the device itself and how long we use it. A smartphone's lifespan begins before it is acquired by the user and continues after it is replaced, and for our systemic understanding, the entire lifecycle and all stakeholders must be considered.

Below, the overall system is considered from the context of the physical materials used. We follow the smartphone from its birth during production through various stages of its lifecycle to the final steps of dismantling and recycling. This analysis is augmented by the identification of information flows that are particularly relevant to the users' purchasing decisions.

To develop solutions for sustainable and resource-efficient smartphone design and for extended usage, it is important to widen the view beyond just the device itself and how long we use it. A smartphone's lifespan begins before it is acquired by the user and continues after it is replaced, and for our systemic understanding, the entire lifecycle and all groups of actors must be considered.

The Smartphone System

The development of solutions for designing smartphones to conserve resources through extended use requires looking beyond just the device and usage span itself. We must follow the smartphone throughout its entire lifecycle, from birth in the production phase through various stages of its lifecycle to the final steps of dismantling and recycling. Information flows play an important role, particularly when it comes to purchasing decisions made by the user.



The first two upstream stages of a new smartphone, "Design" and "Production & Distribution," are the steps taken before we receive a new smartphone, from hardware and software design to raw material extraction, production and distribution. Hardware design informs the selection of materials, components and production processes. When it comes to design, the central responsibility lies with the manufacturers, and it determines the marketability, longevity and recyclability of the device, including its reparability and the longevity of the software, which in turn determines the future viability for updates. As mentioned, the latter has a major influence on the useful life of the devices. Production follows design and directly influences the extraction of resources. The devices then reach end users via various sales channels, either directly or through retailers. Various after-sales options are also offered as part of the sales process. Distribution is directly linked to both receiving and the actual use (the "Ownership" stage), as well as to information and decision-making, and can influence demand though targeted advertising.

In the stages of "Design" and "Production & Distribution", manufacturers make fundamental decisions that have a direct influence on durability, recyclability, reparability and updateability.

In the "Information & Decision Making" stage, users gather information about purchasing options and evaluate them based on their individual requirements. This stage can be repeated several times before a decision is finally made to buy or lease. Purchasing decisions include the complete acquisition of the device and can be made directly, via financing or by instalment payments as part of a mobile phone contract. This could be a new, used or refurbished device. In contrast to purchasing, leasing doesn't automatically transfer ownership of the device to the user after a certain period of time or after a certain amount has been paid. Likewise, leasing offers often include repairs, services or insurance as part of the contract. Leasing options generally include the return and refurbishment of devices at the end of the leasing period, whereby these devices can either be returned to the company's own pool or passed on to third parties. In a B2B context, this decision-making process for business customers may be carried out by a specific person or department within a company before the device is ultimately handed over to the user. Advertising and consulting have a decisive impact on the information-gathering and decision-making process. Consumers encounter advertising directly on various channels and it influences consumer behaviour through indirect effects such as trends and social structures. In principle, these effects can contribute to an acceleration or deceleration of ownership and use by providing strong incentives for new devices and corresponding offers, for example.

In stage of "Information & Decision Making", users make a purchase or leasing decision. The spectrum includes new devices, used or refurbished devices, or the continued use of existing devices.

The "Ownership" stage includes all activities directly related to smartphone use by users. Once the device has been received, its useful life begins, which can be extended by repairs. If a device can no longer be repaired, or if users decide to dispose of the device for other reasons, they usually return to the "Information & Decision Making stage. At the same time, the (first) end-of-use steps begin for the device, with users deciding how they want to dispose of the device. Many put it in a drawer at home and forget about it, while other pass it on to friends or family members, or even sell it privately ("reuse"). Formal handover (through professional return structures, for example) ensures that devices are recycled by way of professional reprocessing structures. In the worst case (loss), smartphones and their resources are lost due to incorrect disposal (such as incorrect disposal in household waste or illegal disposal in the environment or abroad).

The "Ownership" stage is about how consumers use their device. The issue of repair plays a role, as does the fate of the smartphone once it is no longer actively in use.

When users cease using a device, it enters the "Recovery" stage, in which various so-called "R-strategies" can be applied. The device is formally returned for refurbishment, repurposing or recycling. Whereas refurbishment means that the devices begin a new cycle of distribution, resale and use, recycling allows materials and raw materials to flow back into the production process. Repurposing, meanwhile, is an interesting alternative that is currently still underdeveloped. It involves putting the discarded smartphones to a completely new use for an interim period – by using it for specific functions as sensors or communication modules for research purposes. Remanufacturing, meaning the restoration of devices from used components, currently plays a subordinate role in smartphone production because, unlike car parts, for example, it is difficult to separate the sensitive electronic components of smartphones and ensure their quality. In addition, the lack of compatibility between components of different generations and the logistical challenges of transportation to central production facilities make technically and economically efficient implementation difficult.

What happens to the device when the consumer decides to cease using it? Refurbishment, repurpose and recycling: the "Recover" stage focuses on these three "R-strategies".

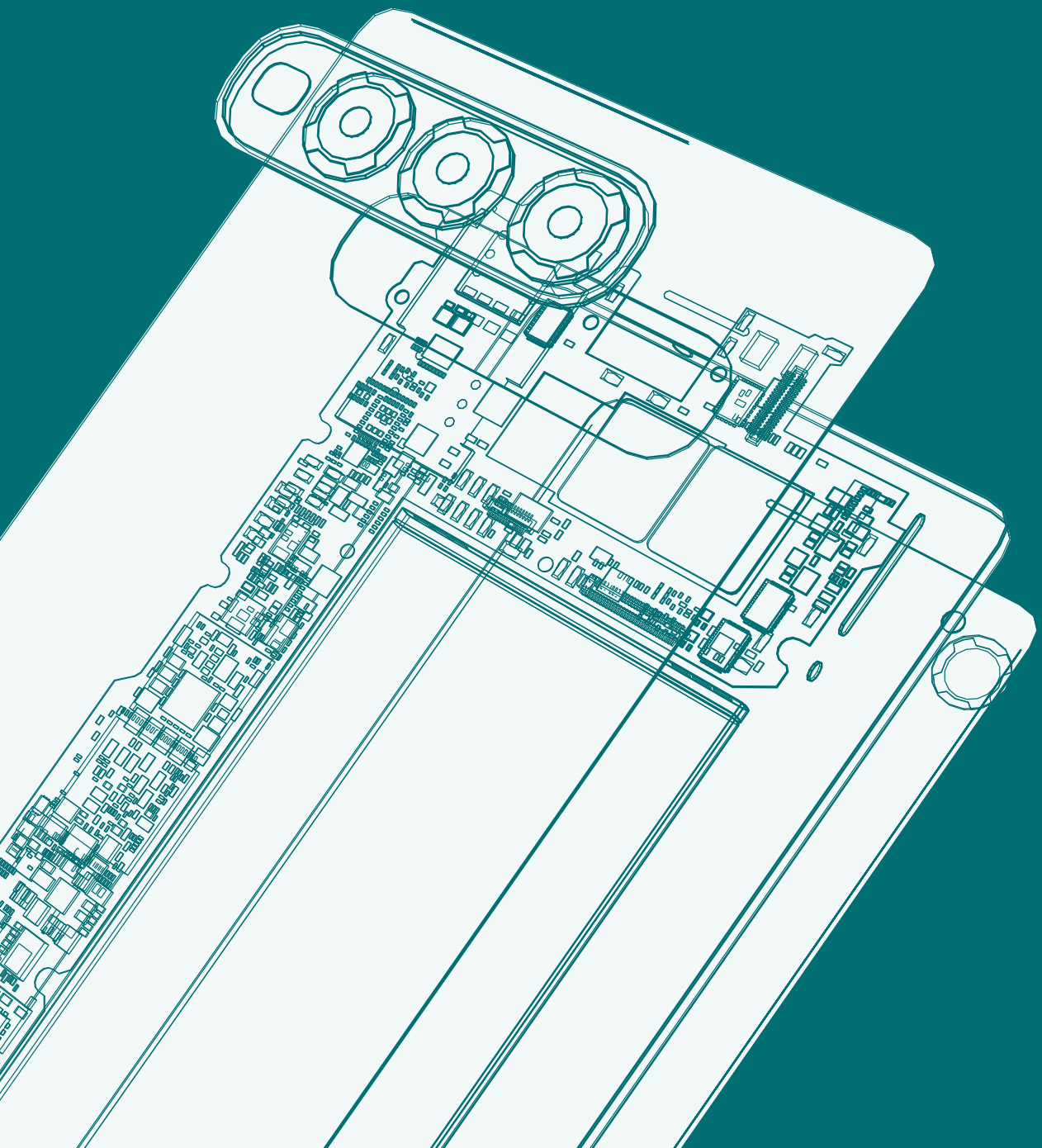
(Operating system) software and licenses play a central role alongside hardware design, as they influence all other steps and areas. The availability of functional and security updates for the operating software determines how long a device remains secure, functional and thus usable. However, the ability of a smartphone to receive updates also depends on hardware, computing power and memory. If the hardware is no longer adequate, no further updates can be performed. Licenses are particularly relevant when third-party providers work with the device, during repairs or refurbishment, for example. Through measures such as digital serialisation or "parts pairing", manufacturers can bind components to a specific device, which means that spare parts cannot be used without a corresponding license. This has a major impact on the cost and, as such, the attractiveness of repairs. Licenses also regulate third-party access to the software for diagnostics and updates. In the B2B sector, "enterprise licenses" for operating systems such as Android are crucial because they qualify devices for professional use.

The "Operating System & Licenses" category is all about software. The availability of functional and security updates for the operating system determines how long a device remains secure and functional – and thus usable.

Transitions between the stages in the system are fluid. They influence each other and can have a direct impact on obsolescence – which in turn has an impact on strategies for extending service life. Even if the individual preferences and decisions of users play an important role, better use of resources and extending the service life of smartphones can only be achieved through the interaction of various options and measures at different stages of the lifecycle. This is illustrated by the example of repairs. If users replace their smartphone because maintenance and repair costs exceed the price of a new phone or they perceive the repair as being too expensive and cumbersome, the responsibility for such a premature change does not lie (solely) with them, but also with the manufacturer and the market. Strategies for extending usage must therefore focus on the entire smartphone system, including manufacturers, service providers and other market stakeholders in addition to users.

THE APPROACH

TEN STEPS TO CREATING A CIRCULAR SMARTPHONE SYSTEM



4

How can we make the existing smartphone system more resource-efficient and therefore sustainable? The answer is clear: Resource conservation translates to extended usage spans, meaning significantly more intensive use of products once they have been manufactured and the resources taken from nature.

To achieve this, the smartphone system described above must change as a whole – and not (just) individual user behaviour. To achieve the goal of extending usage, it is necessary to inform users differently, to support them in making sustainable decisions through retailers and distributors and to enable access to attractive options and solutions for resource conservation from service providers. The circular economy must be practiced and scaled in everyday life.

The design of the smartphone system is therefore a joint task that requires the participation of all stakeholder groups across the entire smartphone lifecycle. There are, however, already numerous approaches leading to concrete steps toward greater resource conservation across the overall smartphone system. The following 10 steps summarise these options for central areas of the smartphone system and describe the accompanying (new) roles and responsibilities of the various stakeholder groups.

It is important to note that all stakeholder groups can – and must – take small steps towards change today so that the new structures and business models can be expanded and scaled in the long term. The self-interest, innovative strength and entrepreneurial responsibility of the actors involved are important drivers of this dynamic, but for a broad and far-reaching transformation of the smartphone system as a whole, additional incentives and framework conditions must be established by policymakers. This will be discussed in the next section.

Recommended actions for the smartphone system

1

MANUFACTURER RESPONSIBILITY FOR DURABILITY / RECYCLING

Provision of affordable replacement parts through R-actors

Open discontinued product lines to open source and open hardware

(Modular) design for repair and refurbishment

Avoid manufacturer-exclusive parts pairing

Extended guaranteed supply of updates and spare parts

Product information: Digital product passport

Long-lasting update strategies

Use of recycled material

MANUFACTURERS

RETAIL, SALES & TELCOS

2

RESOURCE-CONSERVING BUSINESS MODELS AND SERVICES

Services ecosystem: hardware-as-a-service, software updates

Insurance offers

Dual Sim

3

SUPPORTING SUSTAINABLE CONSUMPTION

Redesign of the customer journey: more information on lifecycle assessment and circular options (R-devices)

Make circularity measurable / visible

4

CREATE AWARENESS

Mindful behaviour

Testing out R-devices

Returning instead of hoarding

Smartphones are not fast fashion

USERS

5

PROFESSIONALISED REPAIR SERVICES

Optimised (cooperative) spare parts supply

Partnerships between suppliers, e.g., pooling of devices for immediate replacement

Flexible supply chains and lean warehousing for R-actors

6

CLOSING LOOPS

Umbrella organisation for the coordination of stakeholders

Return structures

Return incentives (deposits, rebates)

7

BOLSTER REFURBISHMENT

Partnerships with repair service providers

Integration as part of the standard offering of retailers, telcos and leasing providers

R-ACTORS

8

ACCEPTANCE THROUGH TRUST

Classification of device status

Orientation and trust: certification of R-devices

Certificates for quality-tested repair, refurbishment

Status-based guidelines for users

Insurance policies

9

FINDING NEW USES

Exploration of repurposing (and remanufacturing) options

10

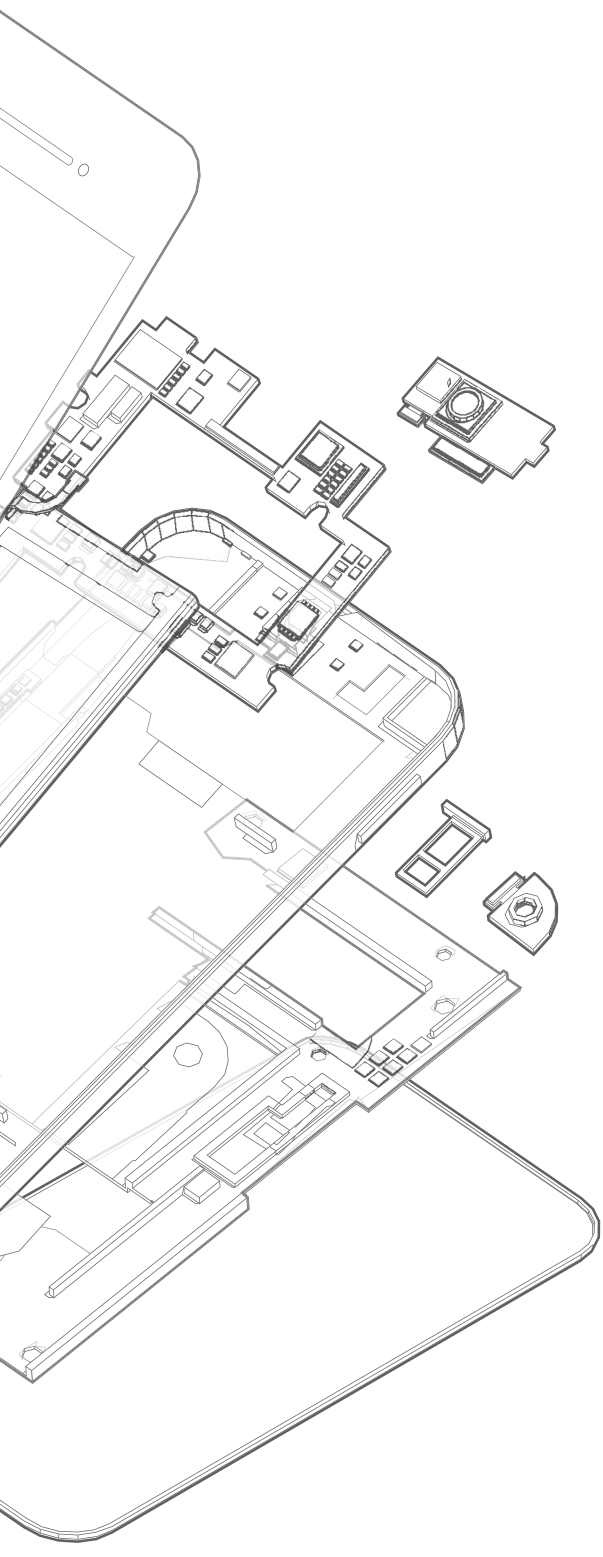
OPTIMISATION OF ELECTRONICS RECYCLING

Improvement of recycling technologies

Closed-loop systems with manufacturers

1. DESIGN FOR CIRCULARITY

Taking responsibility for longevity and recycling right from the manufacturing stage



The first essential starting point is the circular design of hardware, software and licenses. Design informs the marketability, longevity and recyclability of smartphones and creates the basic prerequisites for the smartphone system. In terms of hardware design, circularity can be achieved through reduced variance and increased standardisation of components and models, robust hardware, modularity and the increased use of recycled materials. The latter could reduce the need for primary resources and at the same time shrink the carbon footprint. However, a higher proportion of recycling must not lead to the false impression among stakeholders and users that the adverse effect of shorter usage times can be offset by increased recycling. Extended use can be promoted by modular designs, for example, which can facilitate the repair, refurbishment and recycling of the device through simpler disassembly in addition to opening up the possibility of offering upgrades and greater flexibility to customers. To promote repair and refurbishment, it is necessary to make spare parts available at a reasonable cost. Modularity and standardisation can make a contribution by improving the availability of materials and spare parts. But dispensing with manufacturer-exclusive "parts pairing" – digital serialisation established by linking installed components with the device – also enables the use of third-party spare parts and access to devices for repair and refurbishment. Beyond that, the foundation for the computing power and memory size of the device are also laid during the design phase. Both are factors that influence how long devices can be supplied with security and software updates. In addition to the appropriate hardware design, longevity-oriented update strategies must also include the extended, guaranteed supply of updates and spare parts (for seven years or longer). To promote innovation and further increase the useful lifespans of devices (materials) beyond the warranty period by third parties, manufacturers could open up discontinued, no longer supported product lines for open source and open hardware use.

To provide fundamental support for circular strategies, manufacturers should provide transparent product information as early as possible via the Digital Product Passport (DPP) or sustainability assessments. The EU wants DPP to become a central information carrier in a digitally supported circular economy – a process that can be accelerated through voluntary initiatives. The DPP combines data sets of materials and products – relating to materials used, reparability and recyclability, for example – which can be shared and digitally processed between the various stakeholder groups in the value chain. This increases transparency across the supply chain and enables better cooperation between stakeholder groups.

2. MAKE CIRCULAR OFFERS, CREATE CIRCULAR SERVICES

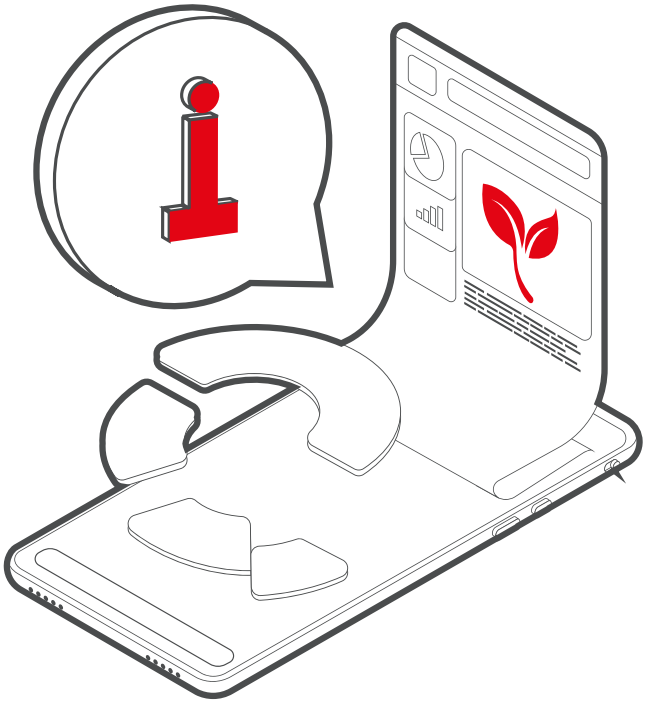
Offer resource-conserving business models and services

There is a need for increased offerings of circular business models and services. An important development here is the shift toward products-as-a-service, also referred to as hardware-as-a-service. Leasing and rental models for smartphones have already become established in the B2B sector and are also well-suited for end consumers, especially for user groups who quickly perceive their smartphone as being outdated and tend to have short replacement cycles. But the service offering for these models should be more circular-oriented through close integration with maintenance, updates, repair, refurbishment and formal return of the devices. While security updates for smartphones are directly related to useful life and obsolescence and should be guaranteed for as long as possible, the provision of fee-based functional updates offers scope for new business models. The addition of insurance offers can increase the attractiveness of these models and thus also the demand for reused devices. More smartphones with a dual SIM function – meaning they support the simultaneous use of multiple SIM cards – also need to be brought to the market. Dual SIM functionality offers various advantages, such as the ability to separate private and business calls, reducing the need to buy second devices and increasing the usage intensity of devices already on the market. The aim is to establish a circular service ecosystem for smartphones to strengthen the reuse, repair and recycling of products.

Just as important as the promotion of circular business models and services is the elimination of business practices that encourage consumers to rapidly switch to new smartphones. This also includes "bundles" from telecommunications companies that offer hardware in combination with mobile phone contracts at a reduced or subsidised price. The incentive to sell more hardware needs to be removed as well. Trade-in models should also follow the guiding principle of conserving resources. If users can trade in old smartphones to receive a discount on a new model, it would encourage the formal return of outmoded devices and could open the door to refurbishment. This could, however, simultaneously boost the attractiveness of new models and stimulate early smartphone replacement and the sale of new hardware. This, of course, depends on the specific design of such offers and the level of price incentivisation.

3. ENABLE CIRCULARITY

Supporting sustainable consumption



In addition to an increased number of offers promoting circularity, consumers must also be supported in their decision-making process. With their broad access to user information, intimate knowledge of decision-making processes and strong customer loyalty, retailers, distributors and telecommunications providers need to redesign the customer journey. This includes providing better information on the ecological impact of specific models, circular offers such as refurbished devices and the relevance of returning unused devices. If this information is integrated into the journey, it can help users make more environmentally friendly decisions. In the long term, these criteria should become just as important as technical data is today. Because users have very different expectations of their smartphones, have divergent reasons for replacing them and have different levels of acceptance of circular offers, various approaches targeting specific groups are essential, as is the integration of offers and information into the user journey. Initiatives to improve the visibility of information on the sustainability of products and services already exist, such as the Eco Rating for mobile phones, initiated by an association of European mobile phone providers, and the calculation model for lifecycle assessment data for electronic devices from refurbed and Fraunhofer Austria.[22] To make circularity measurable and visible, comprehensive and uniform standards, such as environmental certification seals or KPIs, are necessary. Their establishment and implementation must be binding. The Digital Product Passport could help here as well. In addition to data on materials used, reparability and recyclability, the DPP is to be supplemented throughout the product lifecycle with additional information on product use – such as repair history. In addition to benefiting the economic stakeholder groups through greater value chain transparency, the DPP thus also makes relevant information accessible to consumers.

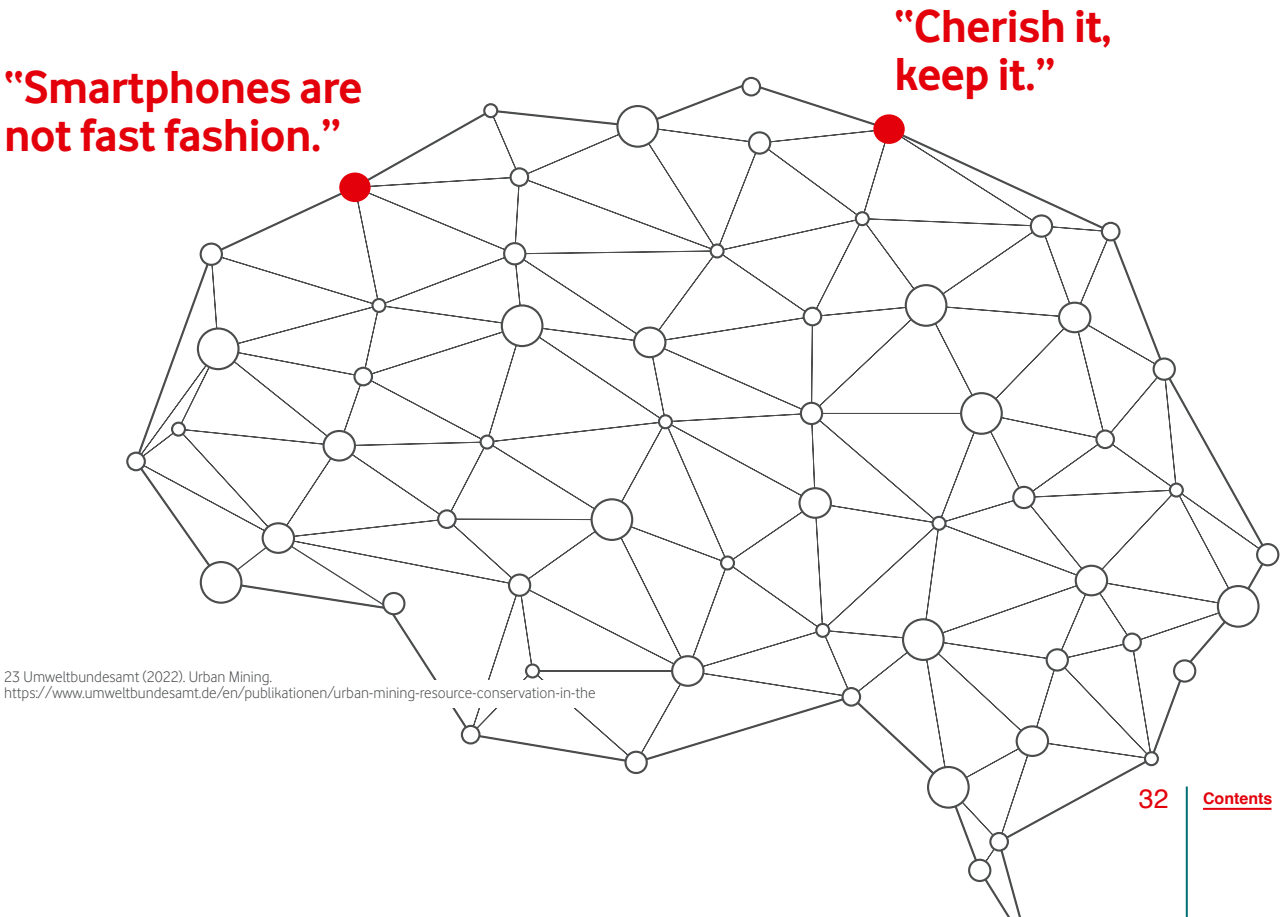
Support for sustainable purchasing decisions also includes the elimination of marketing practices aimed purely at driving consumption. This includes the aggressive direct advertising of a constant stream of new features and improvements to new models, manipulative practices in the selection and decision-making process ("dark patterns"). It also includes misleading sustainability narratives ("green washing") and claims about environmental sustainability ("green claims") that cannot be verified by users using indicators and data.

22 www.refurbed.de/a/pressrelease-refurbed-fraunhofer/ 22 www.refurbed.de/a/pressrelease-refurbed-fraunhofer/ 22 www.refurbed.de/a/pressrelease-refurbed-fraunhofer/ 22 www.refurbed.de/a/pressrelease-refurbed-fraunhofer/ 22 www.refurbed.de/a/pressrelease-refurbed-fraunhofer/ 22 www.refurbed.de/a/pressrelease-refurbed-fraunhofer/

4. CIRCULAR MINDSHIFT

Creating awareness for sustainability

On the consumer side of the equation, meanwhile, user awareness of the ecological impact of smartphones can be boosted, as can knowledge of resource-conserving usage patterns and purchasing behaviour. Public and private sector information campaigns can broaden awareness that smartphones, given the raw materials and rare earths they contain, are too valuable for rapid consumption ("Smartphones are not fast fashion") and can emphasise the importance of a long service life ("Cherish it, keep it"). This also requires target group-specific strategies to address the different motivations and hurdles of users. There are user groups, for example, which likely have an increased need for repairs and whose devices have shorter lifespans (due to a lower emotional attachment to their smartphones and a tendency toward carelessness). They stand to reap the most benefit from educational campaigns urging users to handle their devices with care and to repair them as needed. In addition to incentives to take advantage of repairs and try out refurbished or used devices, it is important to encourage users to formally return their devices. The primary challenge is to encourage all users to return their phones properly at the end of their useful life, including those who purchased their smartphones outright (and not as part of an ongoing contract or leasing model), thus avoiding an accumulation of replaced phones lying unused in a drawer. The importance of device recycling and the opportunities presented by the "urban mine" must also be anchored in consumer consciousness. Urban mining refers to the recovery of raw materials from our urban infrastructure, landfill sites and other durable goods such as smartphones.[23]



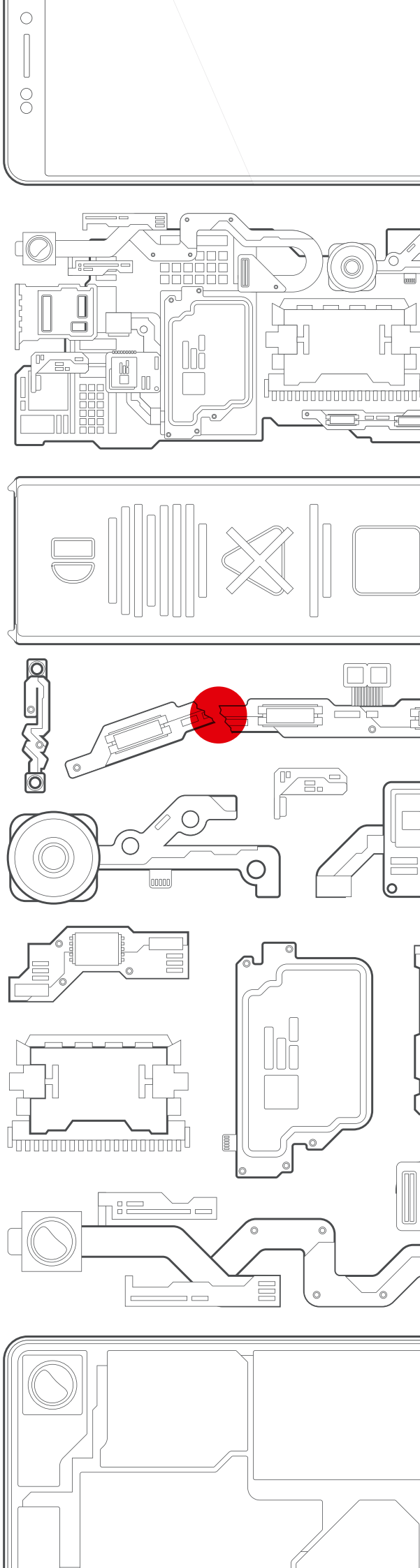
23 Umweltbundesamt (2022). Urban Mining. https://www.umweltbundesamt.de/en/publikationen/urban-mining-resource-conservation-in-the

5. FIX IT

Professionalising repair services

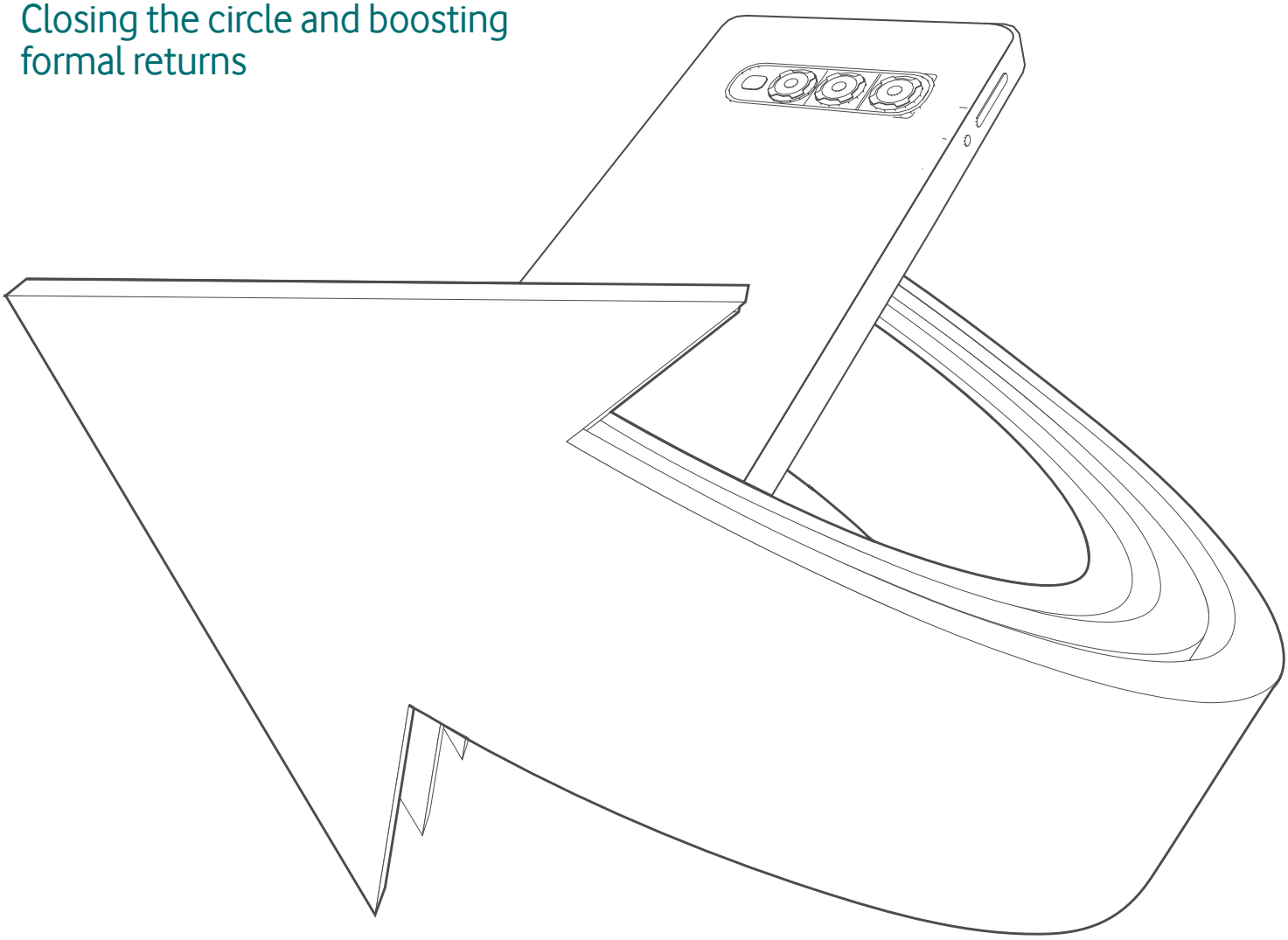
An important step in establishing a circular economy in the smartphone sector is the professionalisation of repair services. This includes a wide range of services that involve various stakeholder groups in the supply chain. Those offering repairs need to expand their partnerships and cooperation with other players in the system and offer their services not only to private customers, but also to refurbishers, manufacturers, retailers, distributors and leasing providers. There are, for example, already repair offers available within the scope of leasing plans, and they should be further strengthened through close cooperation with refurbishing services. The pooling of devices offers the advantage that defective devices can be replaced directly via a pooling system for immediate replacement. In addition to reducing the waiting time for repairs for end users, the efficiency of spare parts procurement can be improved.

An optimised spare parts supply through partnerships can, for example, enable the prompt and demand-oriented procurement of spare parts in metropolitan areas. The aforementioned modularisation and standardisation of components would also help in this regard. Flexible supply chains and lean warehousing at R-actors can not only contribute to an extension of service life, but also to the optimisation of the value chain as a whole. Repair service providers and refurbishers could access a digital platform enabling the rapid ordering of spare parts in line with demand. The advantages of such a structure lie in the reduction of storage costs and the minimisation of environmental impact through needs-based inventory management. In addition, the prompt availability of spare parts would speed up the repair and refurbishment processes, which could shorten the repair time for smartphones and increase overall efficiency and attractiveness. It is important, however, that such a supply system be carefully designed and developed in cooperation with relevant stakeholders in the smartphone value chain – not only to guarantee demands relating to quality, availability and logistics, but also to ensure that the ecological benefits of repair or remanufacturing are not negated by rebound effects and increased logistics costs.



6. GET IT BACK

Closing the circle and boosting formal returns



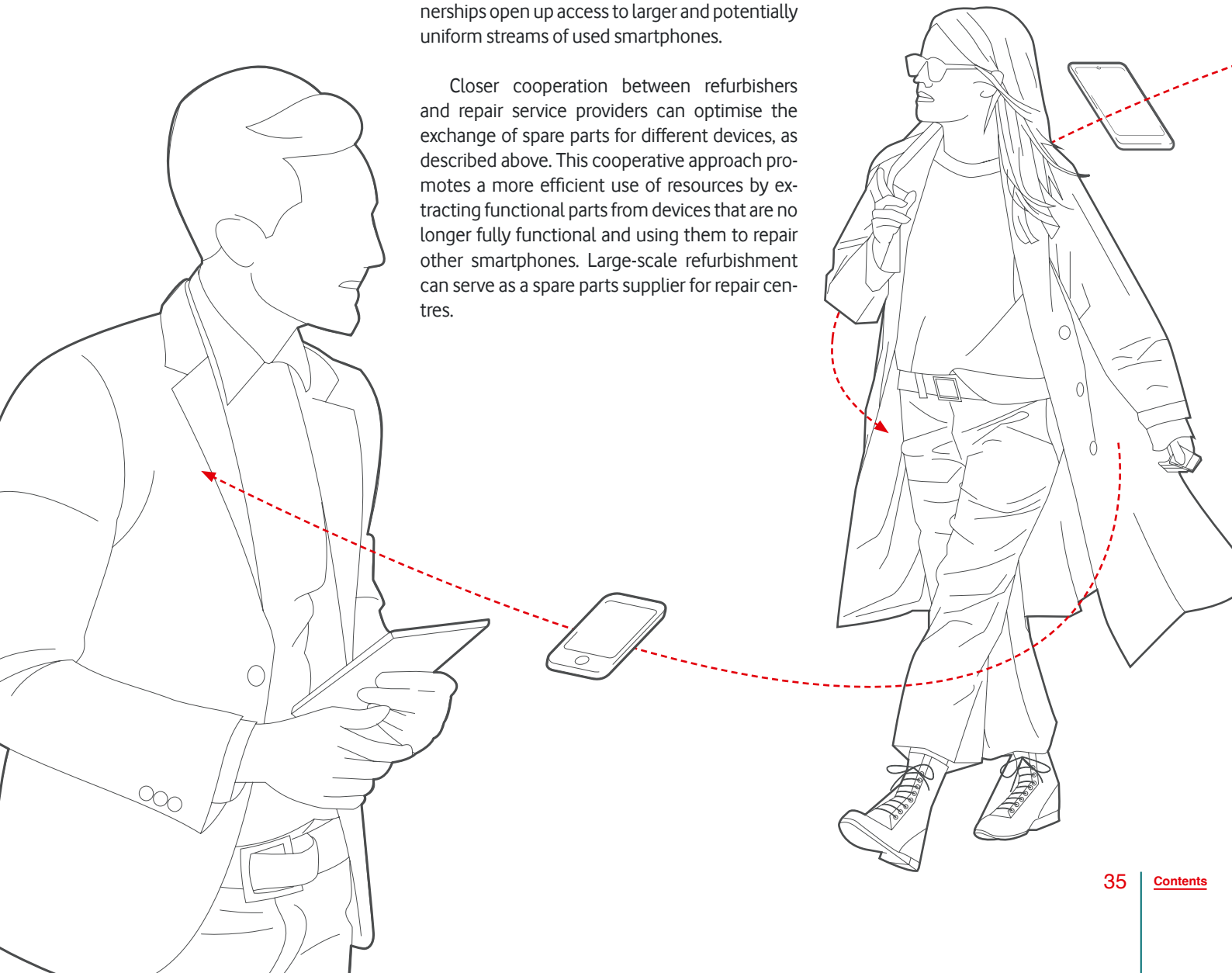
Within the framework of a circular economy, another important approach is the implementation of formal return structures for smartphones. These formal return options would enable large and economically significant material flows to be collected efficiently and in a coordinated manner as part of a circular economy. Bundled quantities of returned devices would promote economic efficiency when it comes to transportation and sorting, and also when determining a specific recovery strategy for a device: refurbishment, repurposing or recycling. One potential for organising such a system would be the establishment of a formal umbrella organisation that manages coordination among various R-actors and focuses on the holistic implementation of a resource-efficient circular economy for smartphones (and possibly other devices). The introduction of additional incentives for the proper return of devices, such as a deposit system for smartphones or return rebates, could serve as a supportive measure to promote these processes and create economic incentives for a sustainable circular economy – and not, as mentioned above, incentives for premature device replacement.

7. PUSH FOR 2ND LIFE

Bolstering the refurbishment of smartphones

The horizontal integration of refurbishment must become a central element of the smartphone system. The refurbishing of smartphones should be established as an integral part of the offerings of retailers, leasing providers, telecommunications companies and also manufacturer brands. It is advisable to offer refurbished smartphones on an equal footing with new devices. To this end, devices that become defective during the contract period should be returned or collected via trade-in programs and, if technically suitable, refurbished. This approach opens up a wider range of choices for end users, extends device lifespans by adding another phase of use and promotes the acceptance of remanufactured devices. For refurbishers, these new partnerships open up access to larger and potentially uniform streams of used smartphones.

Closer cooperation between refurbishers and repair service providers can optimise the exchange of spare parts for different devices, as described above. This cooperative approach promotes a more efficient use of resources by extracting functional parts from devices that are no longer fully functional and using them to repair other smartphones. Large-scale refurbishment can serve as a spare parts supplier for repair centres.



8. MAKE IT EASY TO TRUST

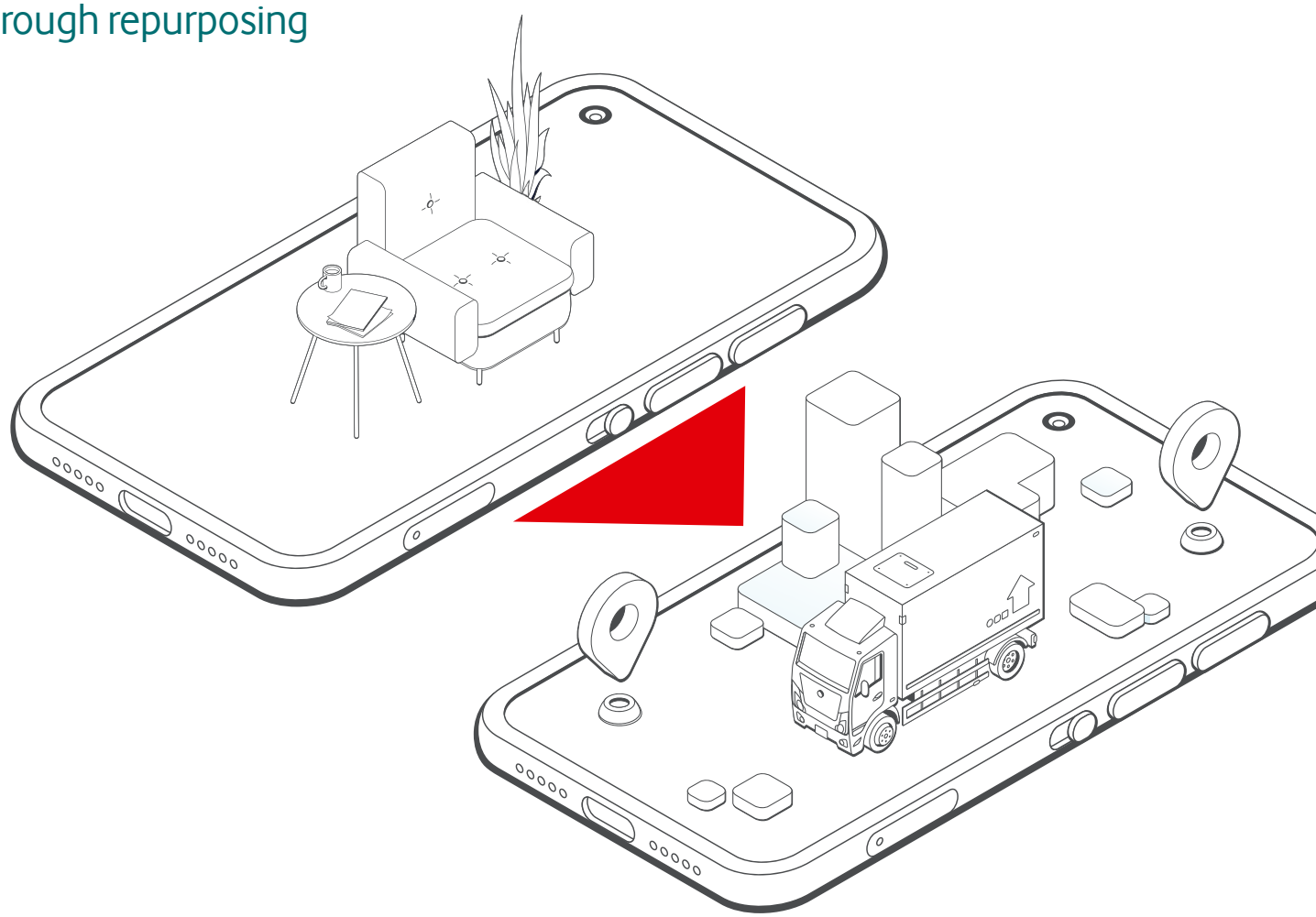
Strengthening acceptance through faith in used devices

To promote refurbishment and repair, confidence in R-devices and R-strategies should be strengthened. Visible and standardised certification of repaired and refurbished devices and certificates for quality-tested services in the area of repair and refurbishment are necessary to provide better orientation and build trust. In addition to high-quality offers, the warranty system for R-devices should also be expanded. Longer guarantees for repaired and refurbished devices reduce uncertainty and risk for end users, making R-devices much more attractive and increasing their demand. This development could be further bolstered by implementing additional insurance options.

The classification of the device status can serve as a guide and help determine the next step in the lifecycle of an individual device. The categories could be defined in particular by the expected remaining service life and the resulting probability of continued use. But the usability of the device in other applications also plays a role. This type of lifecycle check can serve as the basis for recommendations for action across the categories. The classification could provide status-related guidelines for users, but could also prove useful for retailers, leasing and telecommunications companies, refurbishers and formal return strategies.

9. DISCOVER ANOTHER WORLD

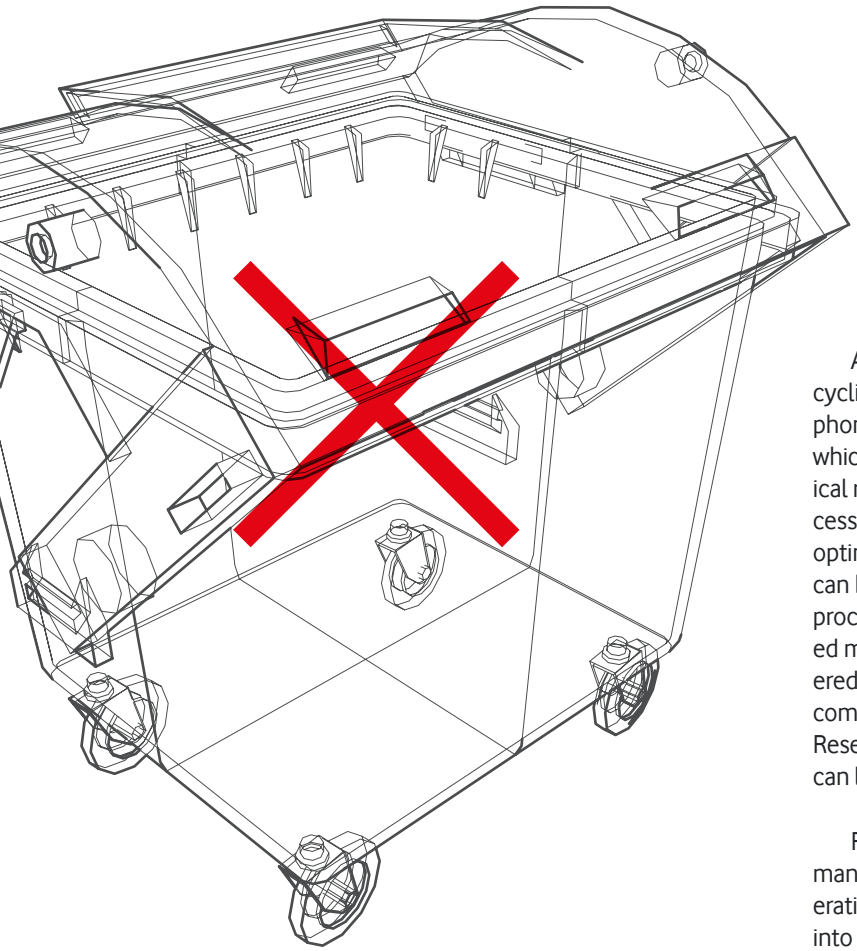
Opening up new applications through repurposing



More attention should be paid to repurposing as an end-of-life (EOL) strategy. Repurposing enables devices that are no longer able to receive security and function updates, but still have usable processors and memory, to be utilised for other purposes. This can include research purposes, other uses such as handheld devices in logistics warehouses or retail and the provision of networked, decentralised computing capacities. To implement repurposing, it is necessary to expand a suitable infrastructure and develop business models and partnerships (between refurbishers and repurposers, for example). It also necessitates the exploration and piloting of (new) repurposing options (possibly also remanufacturing). It is important that once the EOL of the new purpose is reached, it is followed by proper return, spare parts recovery and recycling. Repurposing should be considered as a strategic step before recycling, meaning it is reserved exclusively for those devices that cannot be given a new phase of use through refurbishment.

10. GET THE MAXIMUM OUT OF IT

Optimising electronics recycling



A key strategy for the end of smartphone life is to improve recycling technologies. Because even if the circularity in the smartphone system is very high, there will always be old devices for which no other R-strategy will work – and here, more technological research and development is needed. To support this, the processes for extracting and recycling valuable materials should be optimised such that materials can be sustainably recovered. This can be achieved, for example, through more efficient disassembly processes that extract components and materials in a more targeted manner and thus lead to a higher purity of the materials recovered. Automated disassembly systems would represent progress compared to the shredding process that has dominated so far. Research should be conducted into whether (partial) dismantling can lead to improved recovery of spare parts.

Recyclers should rely more on partnerships with smartphone manufacturers to establish closed-loop systems. Such close cooperation would enable recovered materials to be integrated directly into the manufacturing processes. Opportunities for remanufacturing could also emerge, provided that the reclaimed components are more standardised and can therefore be used in more models over a longer period of time.

More efficient processes for the collection and sorting of electronic waste could also be established. Cooperation with other stakeholder groups and the introduction of a smartphone deposit or a recycling fee, levied when a new device is purchased, could help with collection. During sorting, disassembly robots with automatic device recognition could contribute to efficient processes and also provide a better overview of the market by collecting and distributing data.

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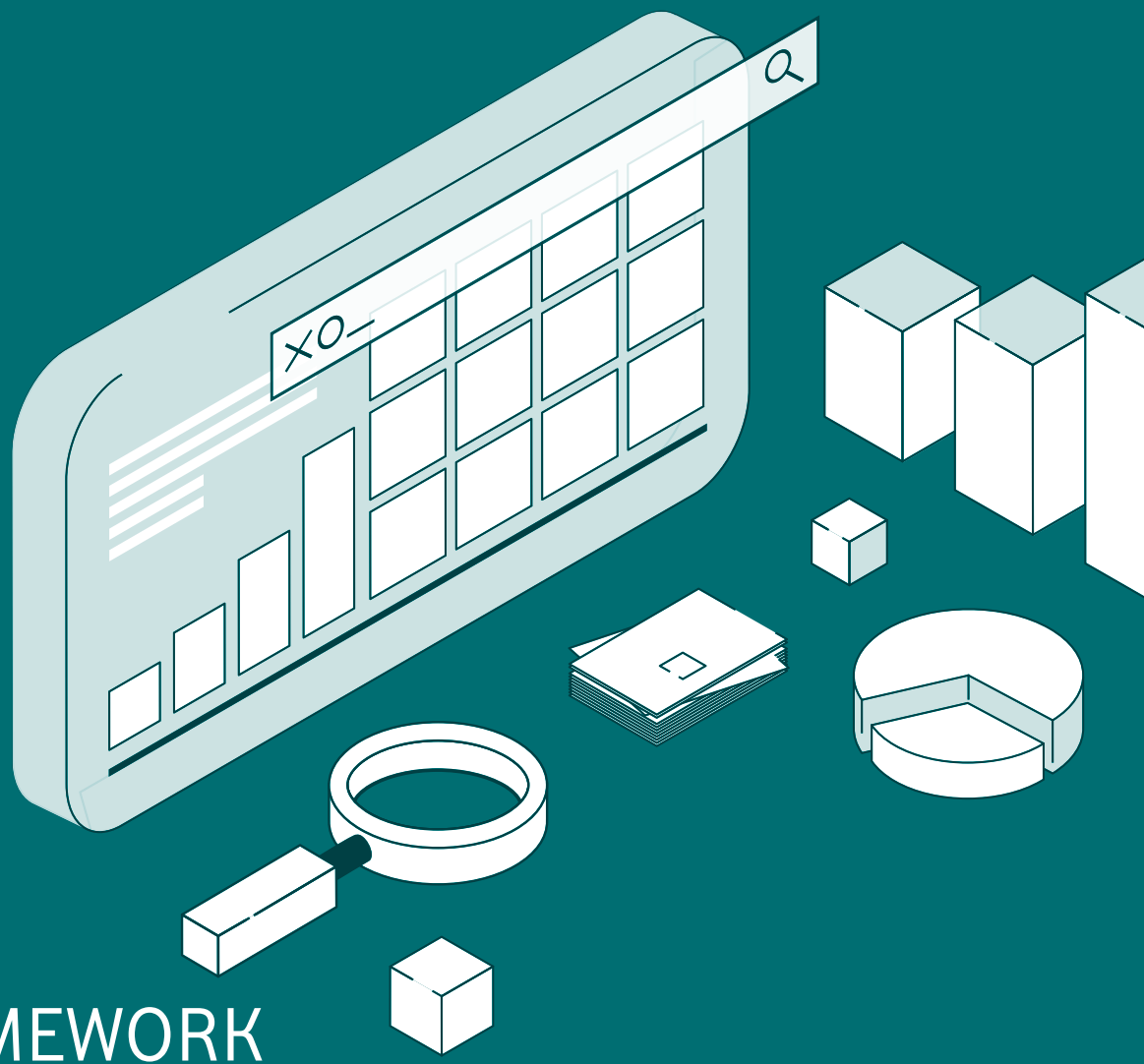


THE FRAMEWORK

ESTABLISHING THE RIGHT INCENTIVES WITH AMBITIOUS POLICY

The ten measures described in the previous section open up opportunities for greater resource efficiency and sustainability in the smartphone sector. It is crucial that the players involved become engaged, seize these opportunities and forge new partnerships and business relationships. For a self-sustaining and reinforcing dynamic to emerge, it should be clear to all players that today's environmentally destructive business models will become less and less profitable in the future – and that, on the contrary (given the increasing risks associated with the supply of critical raw materials, for example), innovative offerings that conserve resources will become increasingly promising and offer long-term competitive advantages.

This is where politics comes into play. Policymakers have the task of shaping the framework conditions for the sustainable transformation of the economy and society. Political policies can encourage and support new solutions and markets through subsidies, steer the type and quality of offerings through regulatory requirements, remove particularly deleterious and dangerous practices from the market through bans, influence market prices and the attractiveness of solutions through tax incentives, and address the flow of information between supply and demand.

For the circular smartphone system outlined above with the ten action points, the incentives and framework conditions for manufacturers, retailers, distributors and telcos, as well as the support and promotion of the (new) R-actors, are of particular importance.

How can policymakers establish incentives and framework conditions promoting designs focused on circularity?

The previous sections have made clear how important the design phase is for the success of the circular economy for smartphones. Important foundations for durability, modularity, reparability, software/hardware compatibility, software security and recyclability are already laid at the design stage. Accordingly, the manufacturers of both hardware and software operating systems have a major responsibility in implementing the circular economy. At the same time, their current business model is geared toward the sale of new devices. Growth and value creation are currently at odds with strategies aimed at extending service life and delaying or avoiding new purchases. Although there are resource-saving business models such as "smartphone-as-a-service", which also represent possible alternatives for manufacturers, these are rarely implemented and scaled up. For these reasons, it cannot be expected that the manufacturers' own interests will provide sufficient impetus for a sustainable realignment of the smartphone system as a whole.

Market transformation thus requires a long-term political strategy. There has been some movement in this area recently. The EU-wide ecodesign requirements, which have been expanded to include smartphones, tablets, mobile phones and cordless phones, are a key instrument for promoting longevity. They include a series of regulations for the hardware design of the devices, which must demonstrate a certain degree of durability and robustness in areas such as drop tests, screen durability, protection against foreign objects and battery performance. In addition, a general USB-C obligation will be introduced in 2024 as the standard interface for charging cables for all small to medium-sized electronic devices on the EU market, a regulation to which Apple, for example, has already reacted by switching its production. The forthcoming Battery Ordinance will introduce stricter requirements for the bonding and composition of rechargeable batteries, which should make them easier to repair and recycle. There are also new modularity requirements relating to the reparability and interchangeability of individual parts in addition to regulations on extended warranties, longer availability of software updates or the provision of spare parts. This also includes a softening of the restrictions for third-party stakeholders through the aforementioned practice of parts pairing.

In sum, a number of predominantly European regulations are now addressing the smartphone market. They will gradually come into force over the next few years and are expected to have an initial incentive effect.

How can actors and markets within the R-economy be strengthened?

To be able to use smartphones longer and more intensively, consumers must be given the opportunity and offered incentives to take advantage of the offerings and services of the R-economy (primarily repair, reuse, refurbishment and recycling). In addition to the measures outlined above to promote circularity designs as a basic prerequisite, policymakers can and must provide additional impetus for circular services.

Price signals from taxes, levies or certificates for energy, CO_2 and, in the long term, raw materials, play an important role here. This would also support the markets for recycled raw materials, which can be further strengthened by setting minimum quotas for the use of recycled materials. Overall, this would increase the cost of using resources for the production of new devices while concurrently making the preservation and reuse of old devices more attractive.

A completely different approach is to support consumers in making use of the offerings and services of the R-economy. Financial incentives such as VAT reductions or tax deductibility would increase the willingness among consumers to take advantage of such offers. In addition to costs, it is also about trust in repair shops, refurbished products or recycling options. Policymakers can address the issue of trust in R-services with specifications on quality standards, data protection regulations and regulations on the warranty system – both for repair services and for refurbished devices.

How can incentives be created to promote circular offerings by retailers, distributors and telecommunications companies?

In addition to promoting circular offerings, access and visibility to those offerings should also be increased. Retailers, distributors and telecommunications companies play an important role here due to their link to consumers. Political measures such as the promotion of repair services, the introduction of quality standards and warranty extensions for repaired devices have a direct impact on retailers, distributors and telecommunications providers. They are called on to adapt to the new standards and are being encouraged to expand their business models in order to offer repair and refurbishment services.

Policy measures can also help provide more information on circular consumption options and raise awareness of their benefits. Specifications for the provision of information at the time of purchase facilitate the assessment of product quality, the expected service life and reparability. This is where tools such as labels (like the reparability index, for example) or the Digital Product Passport come in. According to current plans, the latter will only be introduced gradually after 2028 and will bundle information on things like contents, reparability, recyclability, etc. However, an exact timetable for the product category of smartphones and similar devices has not yet been determined. But it is a process that needs to be accelerated. It is important that instruments aimed at increasing the visibility of circular options such as labels or designations are standardised, comprehensive and binding.

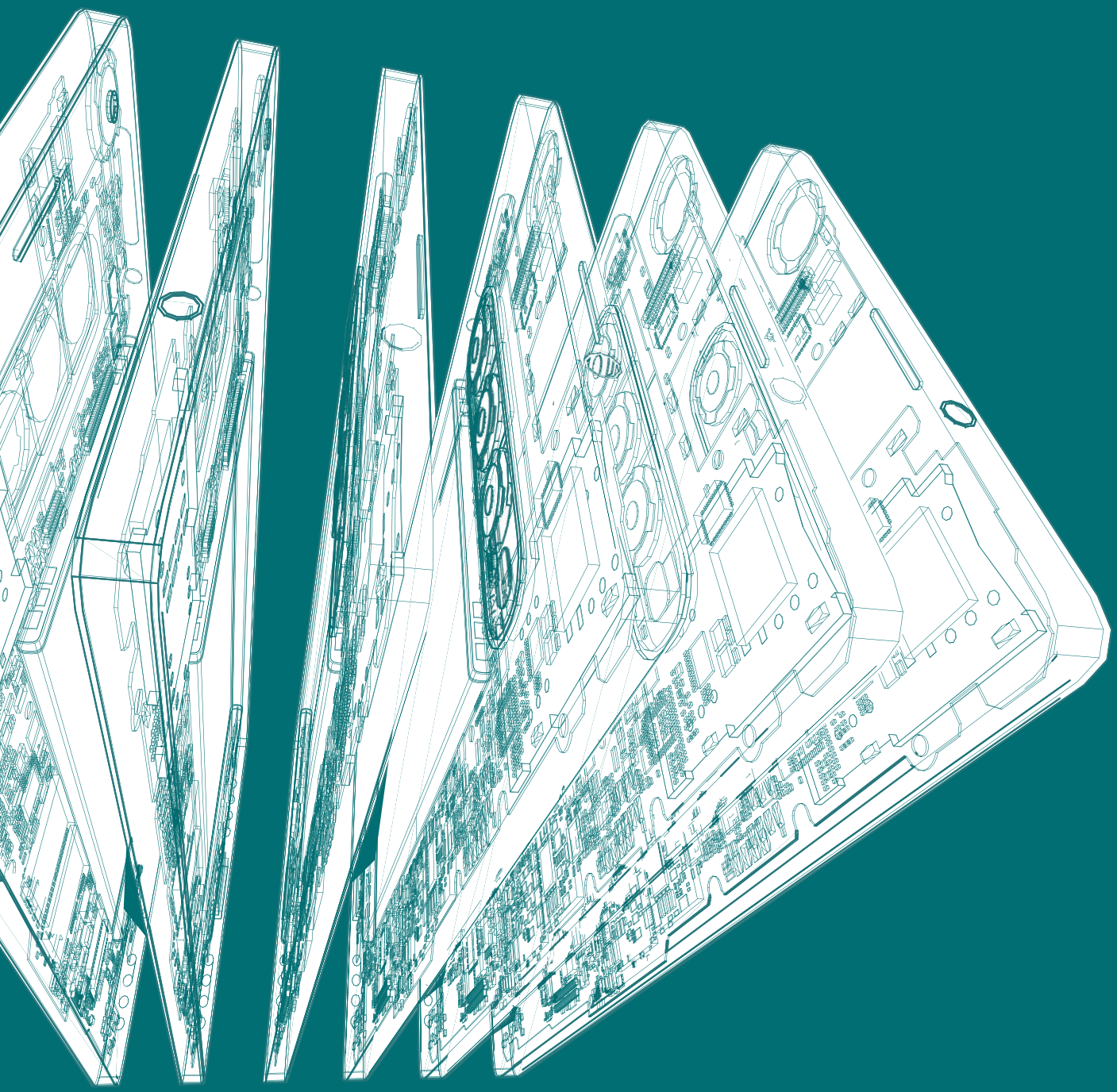
There is also a lack of transparency in terms of the environmental and social impact of the smartphone supply chain. The requirements for systematic documentation and proof of raw material requirements for devices and emissions in the upstream production and supply chains will increase here, particularly in the context of the EU Directive on due diligence in supply chains (EU CSDDD).

Policymakers are (further) called upon to create markets and establish long-term guidelines.

In the areas outlined above, the political task is that of creating the framework conditions and economic incentives for the development of sustainable markets and business models geared towards resource conservation. Important points have been addressed in recent years, particularly through the European Commission's various activities on ecodesign, transparency and reparability. The smartphone product-service system can thus be seen as a positive example of how an entire industry sector can be steered toward sustainability through targeted regulations on reparability and resource conservation.

However, the success and concrete effects of these regulations will only become apparent over the next few years as the obligations are gradually introduced. It will therefore be important to enforce regulations consistently and swiftly; and implementation must be closely accompanied by market surveillance and monitoring measures in order to tighten up inadequate instruments as quickly as possible if necessary.

At the same time, it is important to continue making improvements. Although the first steps have been taken, there is still a lot to do on the path to a truly sustainable, climate-neutral and resource-conserving future. Policymakers and society must continue to send clear messages about the long-term commitment to climate and resource protection and continuously develop the framework conditions and price signals accordingly. This is the only way to harness market forces, create directional certainty for all economic stakeholders, stimulate strategic investment in new, environmentally friendly technologies, products and sustainable business models, and motivate proactive action by pioneering players.



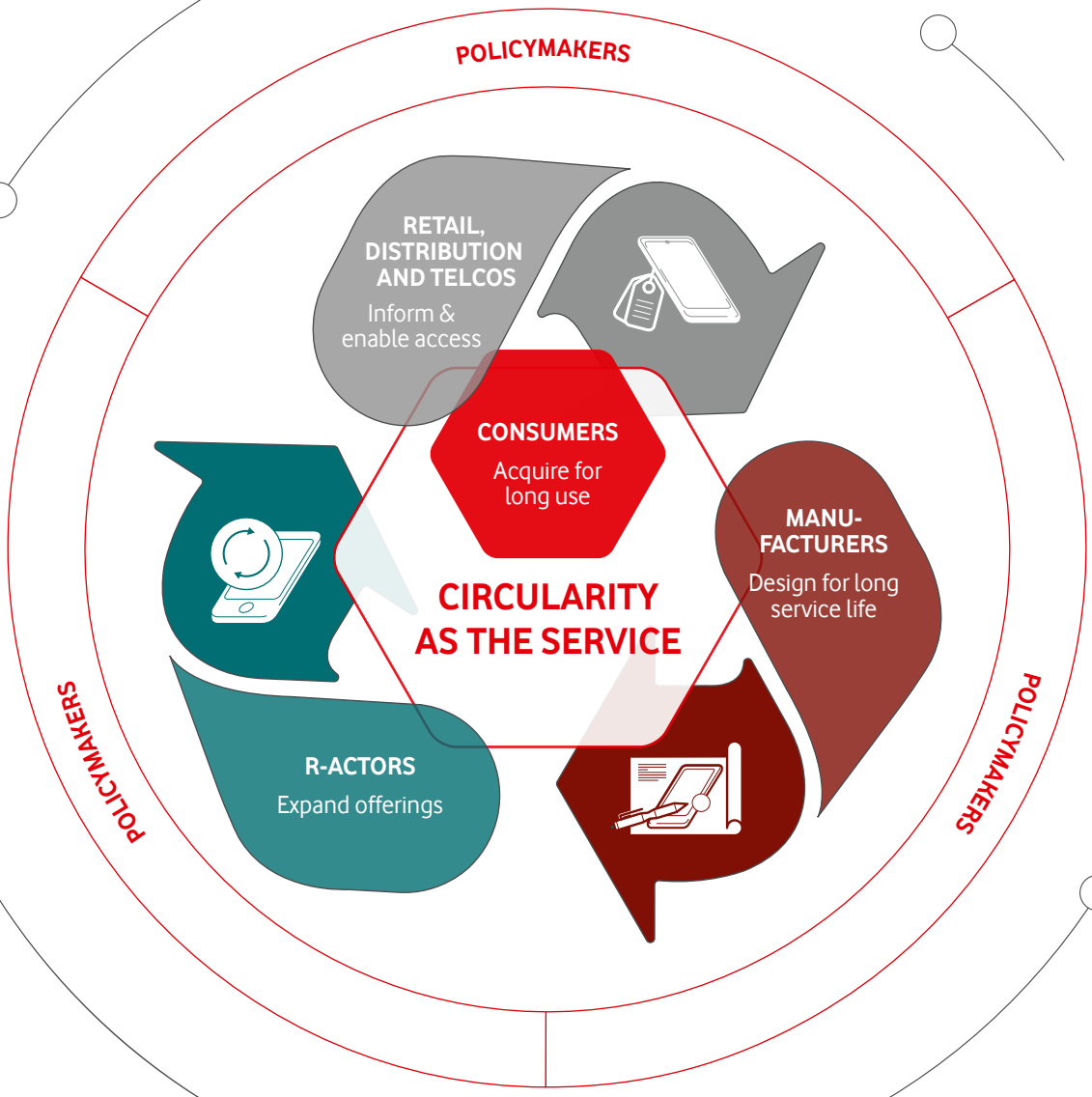
THE AGENDA

MAKING CIRCULARITY AS THE SERVICE INTO A STANDARD

6

Circularity as the Service

Sustainable consumption must become simple and viable for users



The considerations addressed above make one thing clear: We need a fundamental reorientation in the way we use smartphones. The priority can no longer be on getting as many new smartphones into the system as possible. The central goal must be to keep smartphones in the system for as long as possible and to make the best possible use of them. This represents a fundamental change of perspective and a paradigm shift in the smartphone value-creation system.

How could it work? First, there is a need for a change in mindset among us users when it comes to our smartphones. We must become more willing to use second-hand devices and to (continue) to use repaired devices. It is even more important, however, that users are supported in sustainable consumer behaviour by all the players in the overall smartphone system. It's not only the individual usage behaviour that must change, but also value creation surrounding the smartphone.

This discussion paper has highlighted many possibilities and starting points for this reimagination of the overall smartphone system. Manufacturers and software providers can align design, function and lifespan and facilitate recycling once that lifespan comes to an end. Sustainable offers can be made and sustainable decisions must be enabled in retail and on all sales channels, especially among telecommunications providers. This also includes a seamless transition to the services provided by R-actors, such as repair or refurbishment. The barriers to using circular services must be lowered. Policymakers will continue to play a vital role, since the incentives for circular design should be further strengthened and the framework conditions for circular business models constantly improved.

A more sustainable, resource-efficient use of smartphones can ultimately only be achieved through the combined contributions of manufacturers, retailers and distributors, telecommunications providers, recycling stakeholders, and consumers, along with the integration of various strategies at different levels of action. Right now, it's a matter of taking the first steps – all players in the system already have their own opportunities to act.

These opportunities can and must be utilised.

In short, sustainable consumption must become simple and viable for users. This increases the attractiveness and thus the success of circular, resource-conserving offerings. The smartphone as a device should no longer take centre stage – the sustainable use of smartphones must become the central experience for customers. We need circularity as the service.

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