Module 8: Extending the useful life of a device

If we consider that devices are valuable for their computing resources, then we should focus on the right to use a device, not on the right to ownership. Maximising circularity asks us to see devices as collective property that circulates among users until they are finally recycled.

Use and reuse

A digital device is bought for a specific purpose by an individual or an organisation. Over time, it may be no longer suitable for a task, because the task requires more computing capabilities, or because the performance of the device degrades as it wears out. Sometimes this is due to software: the system software is not maintained, and bugs and security problems make the device no longer reliable for normal use. Software updates supporting newer hardware can also have more features and consume more resources, making earlier models of devices obsolete (we call this "technical obsolescence", or when this is done deliberately by manufacturers to drive up sales volumes, "planned obsolescence"). Sometimes hardware components have a short life span, like capacitors or batteries, and the supplier cannot provide spare parts to repair or replace these components. A mix of the two can happen too; for instance, when the driver software for a chip is no longer maintained by the manufacturer, and the software and its documentation are not public. [1] Because of these factors, we can say that the repairability and upgradeability of a device will set the limits of its durability.

What we call the "use phase" of a device refers to both the initial intended use of a device and its reuse for other purposes. The end of one use cycle, when a device is no longer fit for its initial purpose, may create an opportunity for internal reuse for another less-demanding purpose in the same organisation. We can say that the device still has some "use value" for the organisation. When a device does not meet any of the needs of the organisation, is too costly to be maintained or cannot be maintained or repaired by the supplier or a repairer, that marks the end of use of the device in that organisation.

However, the device can still be a resource for other users. Refurbishing the device can extend its useful life, and the device can be put to many new uses, such as in community centres, in clinics, in schools, and in homes.

Therefore, in terms of use we can distinguish between the first or any other cycle of use, the end of use in each cycle, and the end of the last use cycle, or the end of life of the device.

Acting responsibly at the end of use in each cycle

Once an owner or user of a device no longer needs the device, it has to be “data wiped” and restored to default “factory” settings. This is to ensure the privacy and confidentiality of the user. After this, you have several options, including:

- Sending the device back to the manufacturer for remanufacturing, in case some parts can be reused in new devices.
- Donating or selling the device to a new user directly or to an organisation that can refurbish it.
- Getting a recycler to collect the device for disassembly, recovery of resources (materials and parts) and disposal of the e-waste.

Which option you take might be driven by economic, environmental or social motivations. For example, you might want to obtain money from the sale of the device if there is a buyer, ensure minimal environmental impact by calling a reputable recycler, or help unconnected communities to get access to computers.

Depreciation

In organisations, digital devices are usually part of an inventory included in the organisation’s accounting systems. Devices depreciate over time: their accounting value decreases as they are used and wear out, and their cost to the organisation is spread across several periods (e.g. three to five years). However, depreciation in accountancy may be stimulated by tax benefits. It may happen too quickly, even if a device is still usable and even under a maintenance contract. If we depreciate our products we might be treating them as waste with no perceived market value, contrary to the reality in many cases. Even when a digital device has reached the end of use in your organisation, it still has value.

Computers can be used for 7.5 years

An eReuse field study collects and publishes open data about desktop and laptop devices beyond their first use.[2] Nearly all devices it works with are refurbished with reused components, except for new batteries and storage devices when they show signals of failure (called "smart" signals). The eReuse dataset shows durability per manufacturer in total use hours of between 46,000 (5.3 years) and a maximum of 65,000 hours (7.5 years). This is consistent with other studies.[3]

The right to use a device

We can start to look at digital devices from new perspectives. For example, regarding ownership, the user can be the owner or just a custodian of a device (through a *commodate* or loan for use like a book in a library, or through a *servitised* contract with a service provider). From a collective ownership perspective, devices with multiple use phases can be transferred for use, returned "in essence" (without deterioration) or returned "in kind" (consumed, deteriorated) for repair or recycling. From an environmental viewpoint we can see devices from a planetary or footprint perspective: which materials in the device are scarce or abundant? What energy is used in manufacturing the device? What greenhouse gas emissions are involved? What is the e-waste potential of a device? In terms of rights and responsibilities,[4] we are concerned about who has the right to use a device.

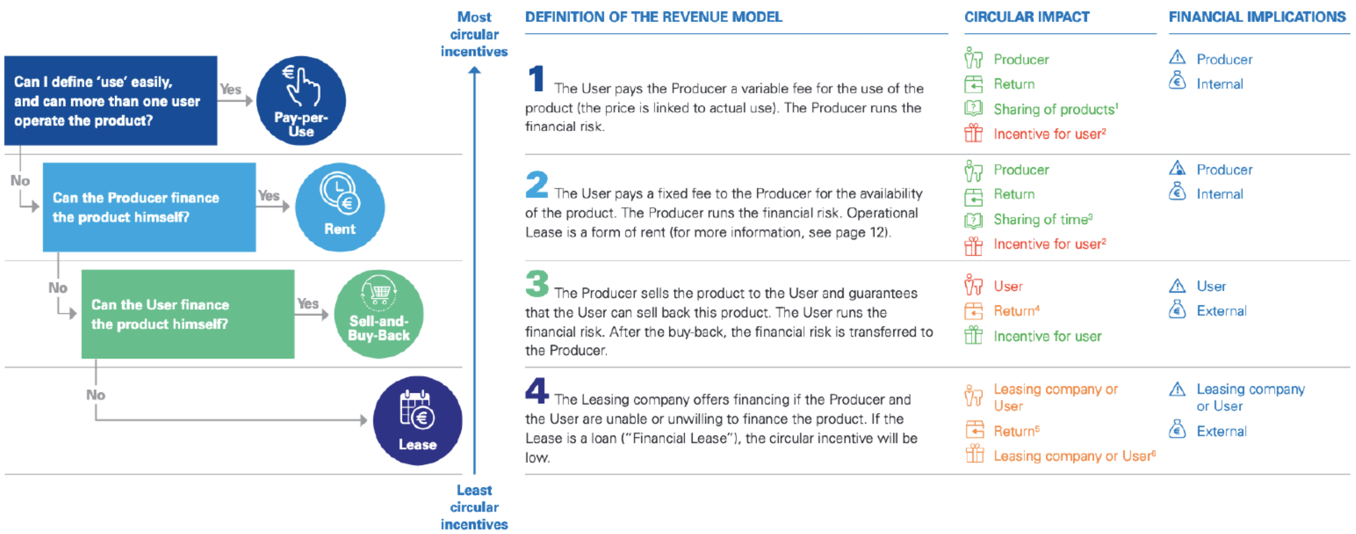

Figure 14: The circular revenue models-ladder. Source: Circular revenue models: Practical implications for businesses, 2019.

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Projects that work towards circularity of digital devices also aim to reduce social inequality. Low-cost computing has become essential to overcome barriers of access to the internet. Reuse makes it possible to find and serve less-demanding users and use requirements where previous generation devices suffice. This was clearly seen in the COVID-19 crisis, where many school children benefited from second-hand computers for home schooling. These were decommissioned devices donated from public and private offices.

Social enterprises that collect, repair and sell these devices provide employment opportunities for individuals. There are also opportunities to create economically sustainable organisations that use circular business models such as pay-per-use, rental, lease or sell-and-buyback. Figure 14 defines and compares these circular business models. Sustainable social enterprises can be driven by both environmental and social objectives, with economic objectives (profit maximisation) only a secondary objective.[5]

Public datasets[6] shared for the eReuse project data commons by a team of users, refurbishers and recyclers involved in the project show that reuse can contribute to approximately a duplication of the life span of personal computers.

This is particularly relevant as an enabler for a servitised model, where, instead of owning devices, organisations pay an annual service fee for an operational computer with a specific performance level. In this model, faulty computers can be easily replaced when they no longer work properly. The device owner is the service provider, rather than the user.[7] The servitisation model makes sense if we consider that we own devices mainly for the purpose and benefits of computing. As noted above, if we want to maximise circularity, we can see devices as collective property (a commons) or at least as a collective responsibility, with devices circulating among users until final recycling.

The importance of traceability and verifiability

Breaking the barriers to circularity requires efficient data, tools and services to optimise each step in the lifetime of a device and ensure the traceability of devices managed as a commons resource system.[8] Gathering details as digital (linked) data about the different milestones of a device along the use life span, from acquisition (ideally tracing back to manufacturing), through multiple use phases, until recycling, allows to assess and even verify, instead of just guessing, the social, economic and environmental impacts of digital devices. These details can be the basis for organisational impact assessments, as well as the basis for public incentives and regulations to comply with sustainability goals. This data becomes even more important as governments try to implement commitments on climate change mitigation.

What is being done?

Right to repair campaigns: Right to repair campaigns want legislation to allow consumers to repair and modify their own consumer electronic devices. As it stands, the manufacturer of devices typically requires the consumer to only use their services or buy a new device.

The European and US campaigns want three things from policy makers:

- Good design: Products should not only be designed to perform, but also to last and to be repaired whenever needed. In order to make products that are easy to repair, we need design practices that support ease of disassembly and replacement of key components.
- Fair access: Repair should be accessible, affordable and mainstream. This means repairing a product should not cost more than buying a new one. Legal barriers should not prevent individuals, independent repairers and community repair groups from repairing broken products. We want a universal right to repair: everyone should be able to access spare parts and repair manuals for the entire lifetime of a product.
- Informed consumers: Citizens want to know if their products are built to be repaired or have to be disposed when breaking. Information on product repairability should be made available at the point of purchase to citizens as well as repairers.

Repair clubs, cafes, projects and parties: There are several citizen initiatives advocating for a culture of repair. Some of these have “repair parties”, where people gather and learn how to fix a range of products, from bicycles to electronics. Examples are the Restart Project, started in the UK, which has several local groups in Europe that organise Restart Parties (a different name for a “repair party”). There is a global network of Repair Cafés, and initiatives like the *Club de Reparadores* (“Repairers Club”) in Argentina, both mentioned in Module 1. Several case studies for this module describe how important repair is for less-developed countries, and how old devices can be put to practical use to help marginalised communities. These include *Computadores para Educar* in Colombia, Computer Aid International’s Solar Learning Lab initiative, and a discussion on the handset repair industry in Nigeria.

Computing as a service: The eReuse initiative, described in the case study for Module 1, works with social enterprises in Spain that collect and refurbish desktop and laptop devices donated by public and private organisations. More than 10,000 devices have been refurbished in the last five years. These computing devices are sold for a price that reflects the cost of refurbishment. A servitisation model is also used. Several recipient organisations, such as schools, prefer to pay a yearly fee for a number of computing units with an agreed performance level. They receive a few additional spare computer units to ensure quick replacement of any devices that are faulty. As a good practice in green procurement, public administrations are also beginning to contract services to equip and maintain public computer and internet access centres using second-hand devices.

Appendix 2: The environmental impact assessment of a reused desktop computer

Let’s look at one example[9] to find out how and why adopting circular models is a good idea. We can roughly estimate the life cycle environmental impacts of a desktop computer from available data,[10] with results illustrated in Table 1. It shows impacts on emissions, materials depletion, and energy demand over the phases of manufacture, use and end of life, with a recovery of impacts from recycling (negative values).

Table 1. Summary of approximate life cycle environmental impacts of a desktop without refurbishment.

Environmental impact category[11]	**Manufacture**	**Use**	**End of life**
Greenhouse gas emissions: global warming potential (GWP), kg CO2e	154	1025	-11
Natural resources: abiotic depletion potential (ADP), kg Sb-e	0.02	0.0002	-0.013
Cumulative energy demand (CED), MJoule	2288	23834	-125

In a “computing as a service” or “servitized” model, we can look at and compare environmental impacts per device and per hour. While Table 1 represents the impact of the first use cycle of a new computer, Table 2 represents the rough expected potential effect of reusing one device after refurbishment in comparison to the use of two new devices. Reuse roughly results in the duplication of use hours by a new user, usually with lighter computing requirements, but the same manufacturing and end-of-life impacts. There is an assumption in the comparison of a 20% improvement in power consumption for the case of a second new device, and the small impact of local refurbishment and local repair is not accounted. We show impacts in three main categories: greenhouse emissions (GWP), natural resources (ADP) and cumulative energy demand (*CED*).[12]

Table 2. Summary of idealised impacts from reuse, five-year baseline use ($I_1 5$): One device with reuse for 2x lifespan ($I_1 10$) compared to two devices without reuse ($I_2 10$) for a period of 2x5 years.

Environmental impact	1 device		2 devices	Impact improvement	
Category	1 use, 5 years I15=M+U+E	Use+reuse: 10 years I110=M+2U+E	5+5 years I210=2(M+U+E)	1 to 2 uses (I15-I110)/I15	2 to 1 devices (I210-I110)/I110
GWP, kg CO2e (total)	1168	2193	2336		7%
ADP, kg Sb-e (total)	0.00718	0.00736	0.01436		95%
CED, MJ (total)	25997	49831	46794.6		-6%
GWP, g CO2e (per hour)	26.7	25.0	26.7	6%	7%
ADP, mg Sb-e (per hour)	0.2	0.1	0.2	49%	95%
CED, KJ (per hour)	593.5	568.8	534.2	4%	-6%

The impact from “use” is highly dependent on electricity production (CO2 emissions), but the increasing use of green and local energy sources tends to reduce this contribution over time (in the two-devices scenario, Table 2 assumes a reduction to 80% of energy consumption for the second).

The servitisation model promotes the expansion of the operational life span of components and devices for as long as possible, which spreads the manufacturing and end-of-life impacts over a longer use period. The savings from reuse show how important it is to ensure the longest life span possible for a device. We can also see that direct reuse, with minor repair, is often more environmentally friendly than reuse of just some sub-parts or components, as we avoid the mining and manufacturing costs of the new parts.

Footnotes

[1] For more information on the barriers posed by chip manufacturers to Android software updates, see: Fairphone. (2020, 18 June). Building a breakthrough for Fairphone 2.
https://www.fairphone.com/en/2020/06/18/fairphone-2-gets-android-9

[2] Franquesa, D., & Navarro, L. (2020). *eReuse datasets, 2013-10-08 to 2019-06-03 with 8458 observations of desktop and laptop computers with up to 192 features each*.
https://dsg.ac.upc.edu/ereuse-dataset

[3] Ardente, F., Peiró, L. T., Mathieux, F., & Polverini, D. (2018). Accounting for the environmental benefits of remanufactured products: Method and application. *Journal of Cleaner Production, 198*, 1545-1558. https://www.sciencedirect.com/science/article/pii/S0959652618319796

[4] Schlager, E., & Ostrom, E. (1992). Property-rights regimes and natural resources: A conceptual analysis. *Land Economics, 68*(3), 249-262. https://doi.org/10.2307/3146375

[5] Burkett, I. (2013, 15 May). Using the Business Model Canvas for Social Enterprise Design. *CSIA*.
https://csialtd.com.au/2013/05/15/using-the-business-model-canvas-for-social-enterprise-design

[6] Franquesa, D., & Navarro, L. (2020). Op. cit.

[4] For an analysis of a mobile phone as a service, see: Johnson, R. (2018, 26 July). Fairphone-as-a-service. *Project Breakthrough*. https://breakthrough.unglobalcompact.org/briefs/fairphone-as-a-service

[8] Franquesa, D., Navarro, L., & Bustamante, X. (2016). A circular commons for digital devices: Tools and services in eReuse.org. In *Proceedings of the Second Workshop on Computing within Limits (LIMITS'16).* ACM. http://dsg.ac.upc.edu/node/914

[9] Andrae, A., Navarro, L., & Vaija, S. (2021). *The potential impact of selling services instead of equipment on waste creation and the environment: Effects on global information and communication technology*. ITU-T Recommendation L.1024. https://www.itu.int/rec/T-REC-L.1024-202101-I/en

[10] See, for example: Ardente, F., Peiró, L. T., Mathieux, F., & Polverini, D. (2018). Op. cit., and Franquesa, D., Navarro, L., Fortelny, S., Roura, M., & Nadeu, J. (2019). Circular consumption and production of electronic devices: An approach to measuring durability, upgradeability, reusability, obsolescence and premature recycling. Paper presented at the 19th European Roundtable on Sustainable Consumption and Production, Barcelona, 15-18 October.
https://people.ac.upc.edu/leandro/pubs/294.pdf

[11] Devices: global warming potential (GWP) in greenhouse gas equivalent units (CO_2e); materials: abiotic depletion potential (ADP) in antimony equivalent units (Sb-e); energy: cumulative energy demand (CED) in Joules.

[12] See explanations of each provided for Table 1.

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