NGI FORWARD

POLICY IN PRACTICE

REDUCING THE DIGITAL DIVIDE BY IMPROVING THE CIRCULAR ECONOMY OF DIGITAL DEVICES

October 2021

NEXT GENERATION INTERNET
INTERNET OF HUMANS

AUTHORS

Mireia Roura, David Franquesa, Leandro Navarro, and **Roc Meseguer**

ereuse.org

dsg.ac.upc.edu/circular

Report design by: **Emma Charleston**
emmacharleston.co.uk

ABOUT THIS REPORT

This report is one of four produced through the Policy in Practice Fund, a platform for policymakers, innovators and civil society to join forces and collaborate on key digital issues through collective action, knowledge-sharing and joint investment in new solutions.

EXECUTIVE SUMMARY

Computers are important for social and economic development. They are key to running modern businesses and play an important role in education. However, nearly 3.7 billion people worldwide are disconnected, 48% of whom are women.[1] At the same time, the connected world discards the equivalent in weight of more than 4,500 Eiffel Towers in electronic devices every year[2] – many of them prematurely – after much shorter consumption cycles than the devices' potential lifespans. This enormous paradox, caused by a disproportionate acceleration of information and communication technology (ICT), that benefits some at the cost of exceeding environmental limits, leaves part of the population disconnected. It also destroys our planet and perpetuates the violation of fundamental rights. To summarize in one sentence, the right to access ICT conflicts with the right to live in a healthy world. This requires reconsidering the economy not as a closed system, but rather as a system in which the sources of supply are closely related to society, which in turn is closely linked to the environment. The strategy of reuse could effectively mitigate impacts on life and society by slowing the consumption of the large-scale schemes and increasing reuse of local and pre-owned devices: creating second-hand markets with shared computers at fair prices whilst increasing awareness and creating a culture of reuse, maintenance and free software use.

The need to achieve decarbonisation whilst continuing to connect populations that want to be connected requires a degrowth or equivalent strategy, with regard to optimising use according to real needs and respecting the 3R rule (reduce, reuse, recycle),[3] combined with an agnostic green growth strategy that provides access to ICT in a way that uncouples GDP growth from environmental damage. This is a difficult challenge with multiple dimensions. How can it be addressed?

Raworth[4] proposes redefining the relationships amongst the four main actors that are embedded and interrelated with society and the environment: the state, families and consumers, the market and the commons. In this project, we sought to delve deeper into the relationships in eReuse ecosystems, where municipalities accompany a joint reuse initiative that inter-cooperates to capture, refurbish and recirculate decommissioned electronic devices. Our aim was tocreate an affordable second-hand market for families and individuals affected by the digital divide and to generate green jobs.

States and public policymakers have key roles to play as economic partners that support families and the market alike, providing public goods and increasing the dynamism of the commons. In our eReuse common ecosystems, we associate the role of states with that of municipalities, as municipalities play a very important role in the transition to a circular and embedded economy. Although international legislation and national governments have ultimate regulatory and fiscal autonomy over waste policy, municipalities have the power to affect such policy through lobbying, closing resource loops,[5] reconciling different interests and providing transparency in supply chains. At the same time, it is possible that its role is to accompany an ecosystem wherein many diverse actors can inter-cooperate to balance demand and supply under common principles and certifications and to offer services such as maintenance, servitisation and support in appropriation and autonomy in digital choices – in sum, to initiate a culture of transition to reuse and extending product lifespans.

Our model of circular electronic devices creates local ecosystems involving many stakeholders with different roles who cooperate under a common governance framework.[6] This means that thousands of devices received each year are managed as common-pool resources (CPR),[7] with agreed-upon rules, compensation, limits and sanctions. The common good to be preserved is the devices' 'use value'. This is why these devices share a common ownership: end users are not the owners of devices, but rather receive a service by using them. Thus, when end users want to get rid of their devices, they must ask the ecosystem. Only if the ecosystem determines that the device cannot be recirculated again is it recycled.

Since 2003, eReuse ecosystems, we call them circuits, have collected, refurbished and manufactured

1 *Measuring digital development: Facts and figures 2020, ITU*

2 *Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). (PDF) The Global E-waste Monitor 2020. Quantities, flows, and the circular economy potential. https://www.researchgate.net/publication/342783104_The_Global_E-waste_Monitor_2020_Quantities_flows_and_the_circular_economy_potential*

3 *A guide to the circular economy of digital devices, Association for Progressive Communications https://circulartech.apc.org/books*

4 *Raworth, Kate. (2017). Doughnut economics: Seven ways to think like a 21st-century economist. Chelsea Green Publishing.*

5 *Circle Economy. (n.d.). The role of municipal policy in the circular economy, Investment, jobs and social capital in circular cities - Insights - Circle Economy. Ademe. Retrieved August 16, 2021, from https://www.circle-economy.com/resources/the-role-of-municipal-policy-in-the-circular-economy-investment-jobs-and-social-capital-in-circular-cities*

6 *Franquesa, D., & Navarro, L. (2018). Devices as a Commons: Limits to premature recycling. ACM International Conference Proceeding Series. https://doi.org/10.1145/3232617.3232624*

7 *https://en.wikipedia.org/wiki/Common-pool_resource*

thousands of decommissioned computers from public and private institutions for second-hand use. We produced an open dataset[8] of devices and parts that included over 10,000 computers by the end of 2020. In 2016, the Barcelona City Council decided to support our initiative. We then began to develop policies and practices in compliance with legal and operational standard procedures (secure data wipes, remanufacturing and other needs of the reverse supply chain). This was not easy, and there were multiple barriers to overcome. Finally, a political decision approved by a government commission addressed the problem. Its example was followed by 45 Catalan companies and other regional municipalities. Later, the circuit was partially replicated in Madrid, where three entities inter-cooperated, this time with the political support of private institutions rather than the Madrid City Council.

With our open-source tools and traceability through the final recycling of the devices, we have the information to analyse the ecosystems' regenerative capacities and to evaluate environmental, social and economic impact, taking into account considerations such as the establishment of soft and hard public administration policies, the density and diversity of the ecosystems formed and the analysis of the market configured by families and consumers (i.e. human behaviour).

This project has helped us to draw some preliminary conclusions in this analysis, especially with regard to public policies and the effect of electronic device donations on the common pool of computers we offer in the market. It has also helped us to discuss and share templates with other European stakeholders and to identify patterns and anti-patterns. Some considerations to take into account are as follows.

1. Even if a computer has the potential for reuse, it cannot always fulfil demand-side needs when the demand side has other options.
2. Offering computers that are not adapted to the user's needs can cause significant rebound effects that must be considered.
3. It is not always economically viable to refurbish equipment for which demand is lacking.

Taking these factors into account when managing a pool of community devices is of vital importance.

The study of the Barcelona circuit and interviews with other stakeholders have helped us identify critical impact factors and modify the contractual conditions with our donor partners. Factors mentioned in the report include public participation in demand (not only supply); definition of the boundary between recycling and reuse; compensation for services associated with data wipes, amongst others; commitment to free software to improve longevity; and provision of innovative services driven by public administrations outside of subsidies.

We detail the activities we have carried out so that the experience can be replicated. Although Spanish municipalities such as Sant Boi de Llobregat and Getafe (Madrid) have adapted parts of our templates to create circuits, replicating our initiative in European cities has been challenging during the COVID-19 pandemic. Nevertheless, we have initiated several conversations and processes, some of which are delivering their first fruits.

8 The eReuse dataset: https://dsg.ac.upc.edu/ereuse-dataset

INTRODUCTION

Although the latest devastating IPCC report gives us less than a decade to act effectively to avoid catastrophic climate change,[9] the debate on so-called green growth and degrowth has focused mainly on whether it is possible to ensure economic growth without damaging the planet (green growth) or, on the contrary, growth is incompatible with humanity's survival. Some authors, such as Raworth,[10] have been agnostic as to whether decoupling GDP growth from environmental damage is possible. This agnosticism is interesting because it is not based on the question of either green growth or degrowth, but rather on the question of whether this and that. This possible intersection of the two in-vogue strategies makes sense when discussing the current paradigm of linear consumption of electronic devices and the digital divide. In such contexts, it would first be necessary to promote a decrease in ICT consumption and use, on the one hand, whilst at the same time improving access for the part of the world's population that wants to be connected without increasing environmental pressures.

Currently, billions of new ICT goods are sold annually,[11] after a long and unclear process full of environmental and social blind spots. According to the ITU-T,[12] by 2030, the ICT industry's environmental footprint must be reduced to half of what it was in 2015. However, we are doing the opposite: it is estimated that, by 2040, ICT-related emissions will account for 14% of global emissions[13] due to an consumption increase conditioned by marketing that – despite being proposed as a valid decarbonisation option – is in fact led by institutions that defend the status quo. The same blind spots that occur with regard to social and supply chain issues are also present in the context of recycling electronic devices: in 2020, only USD 10 billion of the total value of the raw materials in generated e-waste (USD 57 billion) was recovered, according to current recycling data.[14]

This disproportionate acceleration of technology benefits some citizens but harms others: namely, the 3.7 billion people who do not have the option to access ICT services. Digital inequality – which results from historical, economic, political and social constructions and is a cause or consequence of other gaps[15] – originated as the effect of a vertiginous advance in technology and as the consequence of a society unable to keep pace with the technology race due to its lower evolutionary and organisational ability.[16]

Amongst the myriad definitions of the circular economy, which cover almost the entire spectrum from degrowth to green capitalism, reuse has been in the spotlight for several reasons. On the one hand, several researchers assert that there can be no decoupling of 'green' growth from the exploitation of the Earth's resources without first ensuring products' longevity, reusability of already built devices and a decrease in consumption. The opposite strategy (i.e. increasing efficiency in production or not promoting changes in human behaviour) may lead to Jevons paradoxes (more consumption), and an insufficient decoupling.[17] Research[18] [19] indicates that reuse of electronic devices is subject to rebound effects, with, for instance, an estimated 29% of smartphones discarded due to the imperfect substitution of recirculated devices for new products. In addition, every loop around the circle creates dissipation and entropy, which are attributed to losses in quantity (e.g. physical material losses, by-products) and quality (e.g. mixing, downgrading). New materials and energy must be injected into any circular material loop to overcome these dissipative losses,[20] making the model more of a spiral than a circle.

9 IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press

10 See footnote 4.

11 Andrae, A., Navarro, L., & Vaija, S. (2021). Recommendation ITU-T L.1024: The potential impact of selling services instead of equipment on waste creation and the environment – Effects on global information and communication technology. International Telecommunication Union. https://www.itu.int/rec/T-REC-L.1024-202101-I/en; and for smartphone sales: https://www.statista.com/statistics/263437/global-smartphone-sales-to-end-users-since-2007/

12 ITU-T L.1470 : Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement, https://www.itu.int/rec/T-REC-L.1470-202001-I

13 Belkhir, Lotfi & Elmeligi, Ahmed. (2018). Assessing ICT global emissions footprint: Trends to 2040 & recommendations. Journal of Cleaner Production. 177. https://doi.org/10.1016/j.jclepro.2017.12.239

14 See footnote 2

15 Alba de la Selva, A. R. (2015). The New Faces of Inequality in the 21st Century: The Digital Gap. Revista Mexicana de Ciencias Políticas y Sociales, 60(223), 265–285. http://www.scielo.org.mx/scielo.php?script=sci_abstract&pid=S0185-19182015000100010&lng=pt&nrm=iso&tlng=en

16 Kurzweil, R. (2012). How to Create a Mind: The Secret of Human Thought Revealed (Viking Books (ed)

17 Parrique, T., Barth, J., Briens, F., Kerschner, C., Kraus-Polk, A., Kuokkanen, A., & Spangenberg, J. (2019). Decoupling debunked – Evidence and arguments against green growth as a sole strategy for sustainability - EEB - The European Environmental Bureau. The European Environmental Bureau. https://eeb.org/library/decoupling-debunked/

18 Zink, T., & Geyer, R. (2017). Circular economy rebound. Journal of Industrial Ecology, 21(3), 593–602. https://doi.org/10.1111/JIEC.12545

19 Makov, T., & Font Vivanco, D. (2018). Does the Circular Economy Grow the Pie? The Case of Rebound Effects From Smartphone Reuse. Frontiers in Energy Research | Www.Frontiersin.Org, 1, 39. https://doi.org/10.3389/fenrg.2018.00039

20 Cullen, J. M. (2017). Circular economy: Theoretical benchmark or perpetual motion machine? Journal of Industrial Ecology, 21(3), 483–486. https://doi.org/10. 1111/jiec.12599

This battery of paradoxes requires sustained examination and pushes us to rethink the idea of the economy as a closed system. Rather, the economy is an embedded system wherein sources of supply are closely related to society, which is in turn embedded in the natural environment. In addition, the situation of vulnerable populations during the COVID-19 pandemic has raised awareness of another acute situation, namely the digital divide. Digital inequality has widened an education divide during lock-downs and home-schooling. It has also meant a barrier to access to procedures that were previously face-to-face and are now telematic. Thus, governments have had to improvise solutions, given their roles as guarantors of universal education (SDG 4).[21] Whilst the linear economy strategy has proven not to be resilient in face of demand peaks that have resulted in disrupted stocks and long delays in distribution, a more circular model – wherein devices are donated, collected locally and refurbished to maximise their lifespans, and ultimately final recycling (within environmental limits) – seems to contribute to the social inclusion of those who use these devices: affordable devices as a commons under a shared property model.[22]

We use the following definition of the circular economy, as a not entirely new idea, to conclude this chapter: 'It is another rehearsal of how to imagine a reconciliation and compatibility of economic and environmental concerns that already was expressed by the terms "sustainable growth", "green growth" and "sustainable development"; the 1990s and 2000s imaginaries of ephemeralization or dematerialization of the economy; and already with the Brundtland Commission's concept of (simultaneous) environmental, social and economic sustainability'.[23]

This report is structured as follows. First, we discuss our concrete experience of a circular economy of digital devices, eReuse and their circuits to identify a specific circular ecosystem that can facilitate the understanding of the other measures. Second, we describe the activities carried out in our project, which in turn is structured around two chapters: an impact analysis of a municipal circuit, followed by our conversations with other stakeholders and municipalities regarding replication of circular ecosystems in their contexts. Third, we summarise our findings and outputs and their validation with other stakeholders in order to frame the legal clauses that have been defined in our project. We end the report by reflecting on the process and identifying insights useful for policymakers and other innovators.

21 https://en.unesco.org/themes/education2030-sdg4
22 *Elinor Ostrom. 1990. Governing the commons: The evolution of institutions for collective action. Cambridge university press, Cambridge, UK*
23 *Thomas Völker, Zora Kovacic & Roger Strand (2020) Indicator development as a site of collective imagination? The case of European Commission policies on the circular economy, Culture and Organization, 26:2, 103-120,* https://doi.org/10.1080/14759551.2019.1699092

EREUSE

Balancing social and environmental needs and using creative experimentation in communities are key concerns in sustainable development. eReuse is an initiative and action-research project that, since 2015, has iterated over research and activism to understand, develop, apply to communities, evaluate and scale up the circular economy of digital devices.[24]

Public administrations, companies and local circular economy entities have formal, scalable and sustainable reuse partnerships, which we call circuits, in which digital devices circulate for multiple life or use cycles with traceability, accountability and a guarantee of proper recycling after the last use cycle. Through these circuits, city councils deliver device surpluses to citizens and organisations, with the effect of creating inclusive jobs in transport, refurbishment, support and recycling as well as starting or accelerating efficiency and scaling up of local exchanges and markets for second-hand computers.

The users of this pool of devices are citizens who prefer second-hand devices for environmental or affordability reasons. Examples include citizens at risk of exclusion, who are supported or advised by public social services, and organisations demanding larger volumes of devices, such as schools, social enterprises and environment- or budget-concerned public and private organisations. Citizens benefit from these pools of devices due to their lower economic and environmental cost and through the creation of local jobs in social and commercial organisations for device collection, refurbishment and support (servitisation, or computing-as-a-service) by locals for locals.

In a typical circuit, a donor organisation (public or private) donates decommissioned devices, which are collected by a social enterprise and brought to a refurbishment facility operated by a social enterprise or reuse centre. There, the devices are put in a rack to be inspected and wiped of user data, tested and reinstalled with (usually) a Linux operating system as well as our eReuse open-source software tools.

Those that do not pass the test are sorted out for recycling and recorded in our system as prepared for recycling. Those that pass the test are cleaned, checked in more detail, sometimes upgraded (in terms of battery, RAM and storage), labelled and stored for sale. The cost of the process is sometimes sponsored by a third party, although it is recommended that the final beneficiary contribute something as a commitment. Usually, social support or public organisations, but sometimes individuals, acquire these devices, which are brought to end users under the condition of committing to return the devices to the intermediary organisation after usage for another refurbishment or final recycling. The eReuse software records all these transfers and can generate a complete provenance log for each device about its lifespan without revealing any personal details about users.

To organise device donations and establish limits and commitments on end-user ownership to ensure correct recycling, we have developed clauses and agreements with public and private device donors, social organisations (NGOs) working with end users, and social enterprises involved in social inclusion programmes working with refurbishment and recycling. These agreements allow us to obtain data about devices (chain of custody), aggregate data and analyse social utility (usefulness of computing hours enabled) and environmental impact (CO2 savings). We have also detected growing interest in all these templates and agreements, which is why we developed this project.

24 *eReuse poster: the circular economy of digital devices, 2021 ACM Compass,* https://dsg.ac.upc.edu/node/928

DESCRIPTION OF PROJECT ACTIVITIES

As previously mentioned, it is vitally important to evaluate the impact of a reuse circuit whilst simultaneously modifying the public policies that regulate the state's relations with the commons, with the objective of creating an efficient common pool of resources (CPR)[25] with a system of agreed-upon rules and sanctions, as well as shared open tools, procedures, open data and services. The CPR of the circuits works as long as there exist the minimum stakeholders (donors, refurbishment technicians, and users) with minimally stable demand and supply to ensure efficient processing. Moreover, maintenance and support for final users are needed to overcome barriers related to user behaviour and ensure the longevity and substitutability of primary materials.

As mentioned above, one part of the project has evaluated the regenerative capacity of the Barcelona circuit. The other has established and maintained contacts and conducted interviews with other stakeholders to replicate the initiative and explore related policy implications. This chapter is structured in two sections. The first is devoted to analysing the impact of the Barcelona City Council's donations, relying on the literature and the observations we have made of other European experiences. In the second section, we describe the actions we have taken and are promoting to replicate good practices elsewhere.

IMPACT OF REUSING A COMPUTER IN THE BARCELONA EREUSE CIRCUIT

In Barcelona, we have (as of July 2021) 1,079 devices in shared property as a device commons, with more under individual property regimes.[26] The devices have been donated by 45 donors (public and private) and received by 84 entities, including schools, public facilities, NGOs and final beneficiaries. Refurbished devices are prepared by workers at six social enterprises and reuse centres associated with the Barcelona circuit. Devices' refurbishment costs (calculated as processing costs, since devices are donated) have ranged from €40 to €140 each. We based our subsequent analysis on these data.

Environmental impact of municipality donations

Thanks to our software tools, reuse centres operating in the circuits can capture hours of use during the first lifetime of the device, enabling us to quantitatively determine intensity of use and differentiate between public and private donations.

For private companies, first uses typically last three to five years[27] IT asset management supply companies tend to replace entire fleets of laptops at three-year intervals for reasons like maintenance efficiency, rather than functional obsolescence, and following the usual rapid accounting amortisation periods.[28] This rapid technological development risks premature obsolescence and underutilised lifetimes.[29] This, in practice, translates into the following learnings.

Our tools have recorded an average intensity of first use on computers donated by private companies of 12,770 hours. After being refurbished and traced, these devices replaced the functionalities of new devices, achieving durations of more than two years. Although our tools install Linux-based operating systems by default, the majority of users who purchased these devices switched to Windows 10 with almost no reported problems in functionality (with the exception of the lowest-performance devices, which simply cannot run this operating system).

Whilst private organisations seem to depreciate items every three to four years, given the fast amortisation periods, the current lifespans of Barcelona City Council devices are eight to nine years for a computer park of around 12,000 computers, according to information from semi-structured interviews with technicians in the aforementioned municipality. In our analysis, devices donated and distributed by public administrations had an average of 17,049 use hours during their first life – 4,270 more than their private counterparts. In addition, an analysis of processors, RAM and hard drives showed that devices donated by public companies had fewer opportunities to be reused, even if they were reusable, due to lack of demand. With the recirculated devices, we detected several discards motivated by a change from Linux to Windows that made the device unusable (considered later in the social impact chapter).

25 Elinor Ostrom. 2008. The challenge of common-pool resources. Environment: Science and Policy for Sustainable Development 50, 4 (2008), 8–21. https://doi.org/10.3200/ENVT.50.4.8-21
26 Roura, M., Franquesa, D., Navarro, L., & Meseguer, R. (2021). Circular digital devices: Lessons about the social and planetary boundaries. LIMITS Workshop on Computing within Limits. https://doi.org/1428/bf6fb269.3881c46e
27 Prakash, S., Kohler, A., Liu, R., Stobbe, L., Proske, M., Schischke, K., & IEEE. (2016). Paradigm shift in green IT – Extending the life-times of computers in the public authorities in Germany. 2016 Electronics Goes Green 2016+ (EGG) conference.
28 Copper8. (n.d.). Circular Revenue Models: Required Policy Changes for the Transition to a Circular Economy. https://www.copper8.com/en/circulaire-verdienmodellen-barrieres/
29 Proske, M., Winzer, J., Marwede, M., Nissen, N.F., Lang, K.D., 2016b. Obsolescence of electronics – the example of smartphones, Electronics Goes Green 2016. Berlin, Germany

Regardless of market demand, the question is whether it makes sense from an environmental point of view to recycle devices with low computational power. The answer could be yes, according to the literature. Although the market is still not very robust for several reasons, reusing a device or mobile phone always makes sense as long as we can find a use case. As a result of the rapid rate of obsolescence for personal computers, the dominant environmental impact is in their production phase: the total energy used to manufacture a desktop computer could be up to four times as much as the electricity it consumes whilst in use.[30] This is not the case for other types of devices, such as washing machines and refrigerators, where age is a decisive factor.[31]

The contribution of use extension to the total impact reduction for any impact category depends on reuse efficiency and the duration of the use extension.[32] According to this last source, the environmental impacts of using second-hand laptops could be 39% to 50% lower than for a new laptop. Meanwhile, Hischier[33] points out that such impacts could be between 50% and 10% depending on age, functionality and ability to replace a first-hand asset.

At eReuse, we have developed tools that allow us to estimate devices' environmental impacts based on whether they are computer towers or laptops, their computing power and whether replacement components have been used to repair them. In sum (since it is not the purpose of this report to delve into the issue), computer towers with low use value have mean environmental savings of 9% to 55% in a linear scenario, whereas towers with medium or high use value have an impact of 38% to 56%. For laptops, impact ranges from 63% to 82% depending on use value. For a smartphone in 2016, the scenario of 100% recycling results in 39 Kg CO2e, compared with 5.2 Kg CO2e in the ideal circular model of no recycling, 5% remanufacturing and 95% reuse – a factor of close to eight.[34]

However, there is little analysis of what happens next in practice or the reuse ability of substitutions for first-hand device purchases. Demand substitution is an important concept in the circular economy. It happens only when a secondhand device satisfies demands and thus perfectly replaces a new device. In other words, it provides the same utility to the beneficiary, reducing the demand to manufacture more new devices. In a paper about electronics products

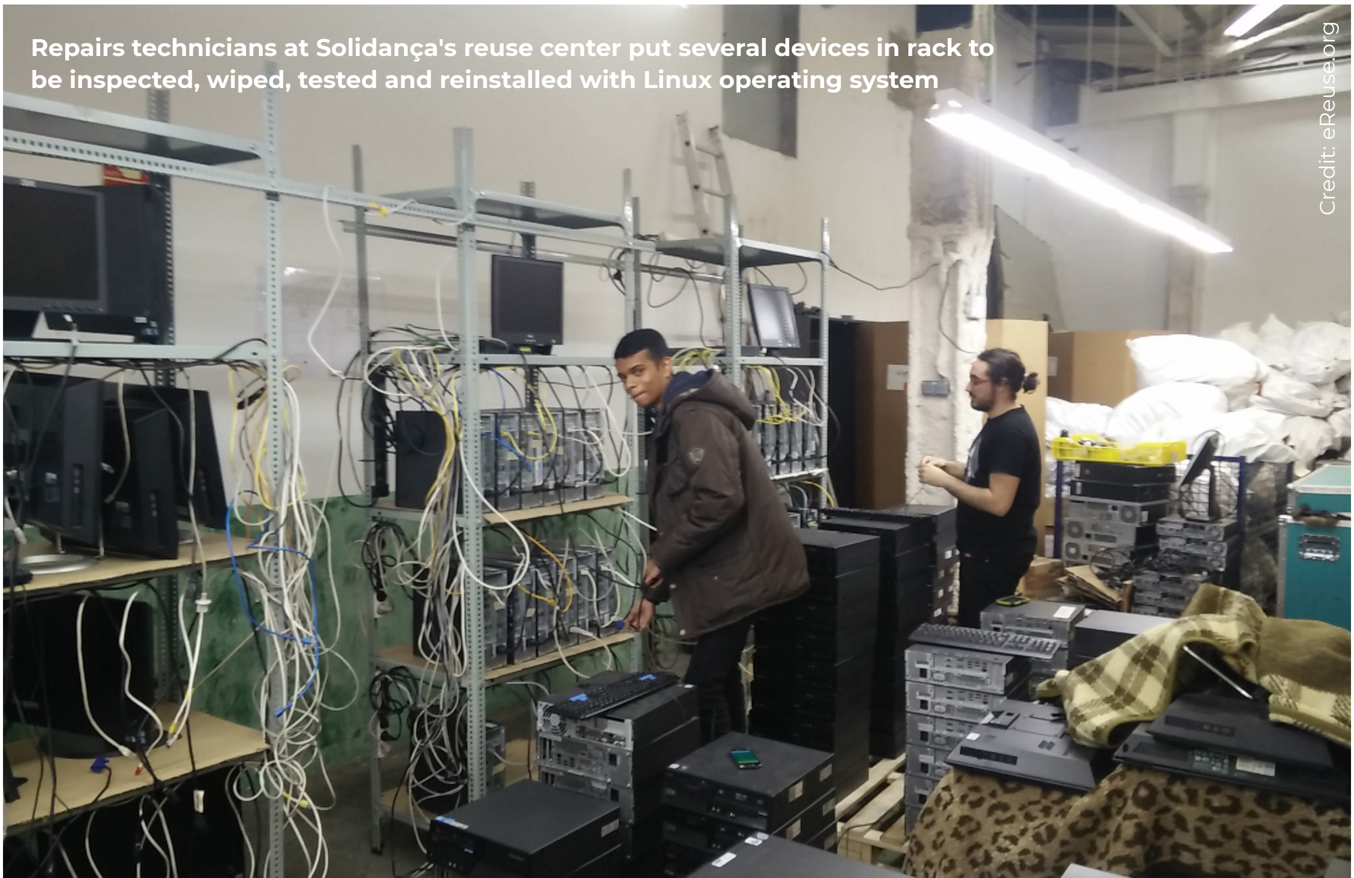
30 Hischier, R., & Böni, H. W. (2021). *Combining environmental and economic factors to evaluate the reuse of electrical and electronic equipment – a Swiss case study. Resources, Conservation and Recycling, 166, 105307.* https://doi.org/10.1016/J.RESCONREC.2020.105307

31 Williams, E., Kahhat, R., Allenby, B., Kavazanjian, E., Kim, J., & Xu, M. (2008). *Environmental, social, and economic implications of global reuse and recycling of personal computers. Environmental Science and Technology, 42(17), 6446–6454.* https://doi.org/10.1021/ES702255Z

32 André, H., Ljunggren Söderman, M., & Nordelöf, A. (2019). *Resource and environmental impacts of using second-hand laptop computers: A case study of commercial reuse. Waste Management, 88, 268–279.* https://doi.org/10.1016/J.WASMAN.2019.03.050

33 *See footnote 29.*

34 *A. S. G. Andrae, "Life-Cycle Assessment of Consumer Electronics: A review of methodological approaches," in IEEE Consumer Electronics Magazine, vol. 5, no. 1, pp. 51-60, Jan. 2016,* https://doi.org/10.1109/MCE.2015.2484639



Repairs technicians at Solidança's reuse center put several devices in rack to be inspected, wiped, tested and reinstalled with Linux operating system

and obsolescence in a circular economy,[35] the authors summarise the concepts related to product obsolescence, although they emphasise that there is no consensus on the different definitions. Longevity is strongly conditioned on user behaviour but is also an effect of disuse of a functional product for subjective reasons. The latter is called 'relative obsolescence'. Absolute obsolescence is primarily related to the useful life designed by the manufacturer, whereas relative obsolescence is related to the actual useful life.[36]

Within the concept of absolute versus relative obsolescence, optimal lifetime[37] refers to the point at which a product's useful life cycle has reached the optimal environmental, social and economic impact, taking into account factors influencing the product, consumer and socioeconomic context. In practice, it is difficult to identify an optimal useful life due to the multitude of impacts and factors that must be considered, which are in many cases subjective and interdependent. In reality, the actual service life of a product rarely reaches the upper threshold of its designed service life, as emotional and socioeconomic factors jointly influence the product's service life.[38]

Social impact of municipality donations

As mentioned in the previous chapter, reuse is strongly conditioned by user behaviour in terms of how users use and repair second-hand devices as well as the relationship between reuse and technologies. Considering human behaviour is especially important when the end users of the reused devices are affected by the digital divide. The headline '"Just having a computer doesn't make sense": The digital divide from the perspective of mothers with a low socioeconomic position'[39] exemplifies what could happen when devices are distributed amongst vulnerable populations (termed 'providing instrumental competencies') without providing other instruments that facilitate use (substantial competence), especially strategic use (i.e. that which allows the citizen or beneficiary to exit their state of vulnerability).[40]

The implementation of ICT solutions in an area is based on three pillars: infrastructure, training of the population in the use of technology and the services offered to inhabitants there. These three pillars are complementary, and poor implementation of any of them means inability to take advantage of the possibilities offered by new technologies.[41] Competencies in digital use and understanding are two aspects of the multidimensional nature of digital inequality that often go unnoticed in corporate social responsibility and volunteering projects and in the limited budgets of public administrations, which face myriad barriers. However, a computer needs preconditions, such as internet and support, given the large differences between people and their abilities, needs and living conditions and that not everyone has equal access to support channels. In light of this, support for end users is needed to overcome the barriers related to user behaviour and to ensure longevity and substitutability of primary materials used to manufacture new devices

In our experience in Barcelona, 84 intermediary entities (NGOs, schools and public institutions) interceded between reuse centres and the final beneficiary for the custody of 1,079 electronic devices. Many intermediary entities, especially NGOs and social and solidarity entities, have understood and appropriated our model. As a result, they have maintained good longevity of the equipment purchased in eReuse circuits.

In contrast, other entities did not find that our model met their needs, especially for devices with lower use value. When asked about this two years later, they reported that the towers from the second acquisition had been recycled because they did not support the operating system (i.e. they had tried to replace the light Linux distribution we installed with Windows). All of these considerations are relevant if we consider that some computers with low use value were discarded by end users for several reasons: a mismatch between real usage needs and initial plans, expectations for Windows or certain applications (Microsoft Office) when receiving computers with Linux operating systems, and computers being overloaded when reinstalled with Windows. Although minimal-overhead operating systems with good hardware support (such as light Linux distributions) are necessary to extend the lifespan of computers, these organisations' lack of familiarity with Linux or lack of knowledge of the limitations of devices and software may limit expectations in terms of impact.

Apart from the multitude of citizen projects that stress the need to appropriate technologies from sovereign

35 *Bachér, J., Dams, Y., Duhoux, T., Deng, Y., Teittinen, T., Fogh, L., & Mortensen. (2020). Electronics and obsolescence in a circular economy — Eionet Portal. Eionet. https://www.eionet.europa.eu/etcs/etc-wmge/products/electronics-and-obsolescence-in-a-circular-economy*

36 *Tim Cooper. 2016. Longer lasting products. Alternatives to the throwaway society. (1st ed.). Routledge, London, UK. https://doi.org/10.4324/9781315592930*

37 *Murakami, S., Oguchi, M., Tasaki, T., Daigo, I. and Hashimoto, S. (2010), Lifespan of Commodities, Part I. Journal of Industrial Ecology, 14: 598-612. https://doi.org/10.1111/j.1530-9290.2010.00250.x*

38 *See footnote 36*

39 *Goedhart, N. S., Broerse, J. E., & Dedding, C. (2019). "Just having a computer doesn't make sense": The digital divide from the perspective of mothers with a low socio-economic position. New Media & Society, 21, 11–12. https://doi.org/10.1177/1461444819846059*

40 *Panadero, H., Gómez, S., & Luque, S. (n.d.). Bretxes digitals: noves expressions de les desigualtats. Retrieved August 15, 2021, from www.ferrerguardia.org*

41 *Orlando, D., Campoverde, G., Verdugo, D., & Danilo, P. (2019). El analfabetismo tecnológico o digital. Polo Del Conocimiento: Revista Científico - Profesional, ISSN-e 2550-682X, Vol. 4, No. 2, 2019 (Ejemplar Dedicado a: Febrero), Págs. 393-406, 4(2), 393–406. https://dialnet.unirioja.es/servlet/articulo?codigo=7164297&info=resumen&idioma=ENG*

options, we analyse below how public administrations can help in this based on our experience and from the perspective of 'public money, public code'.[42] We are running servitisation projects with some public administrations that have opted for responsible and green public procurement of second-hand devices to equip public facilities in vulnerable neighbourhoods in Barcelona. The service is associated with infrastructure setup and maintenance and rental – not acquisition – of equipment. Despite initial reluctance to use Linux or administrative and legal difficulties, the pilot is still working, even for low-value devices. Maintenance and support are key to extending the useful life of devices. This is an interesting scenario that has many roles in the ecosystem and ensures maximum device lifetime and social impact. These activities would fit an equivalent campaign for 'public money, public computers (for reuse)' instead of early recycling.

Several other successful reuse and social experiences strongly associated with final-user support include the Social Services of Barcelona's acquisition of devices to equip a school with an extra assistance room during the partial easing of COVID-19 restrictions (with final-user support from a foundation) and the public purchase of equipment for a school, which then had the final-user support of a community management space. Another interesting case is a contract by a district of Barcelona to refurbish their decommissioned equipment at one reuse centre for internal reuse in a neighbourhood facility.

Economic impact of municipality donations

Demand market substitution is an important concept in the circular economy. It occurs only when a second-hand device satisfies demand and thus perfectly replaces a new device. In other words, it provides the same utility to the beneficiary, reducing the demand to manufacture more new devices. Promoting reuse over recycling (and consequently the need to manufacture a new device from raw materials) may reduce environmental costs by about €45 per PC. 'Those social benefits are mainly generated in the reuse preparation process and distribution activities. Whereas the reuse scenario displays a worse performance in energy consumption, the difference in the distribution stage during the second life cycle originates from the fact that the ready to reuse product is produced locally, while the brand-new product is manufactured and distributed from abroad, mainly Asia.'[43]

There are two interlinked difficulties for reuse centres: access to sufficient and good-quality used equipment, and weak accompanying, supporting, incentivising or enforcing legislation to access good-quality devices. Securing constant access to quality products and processes is amongst the most important factors required for success.[44] In our experience, there was an initial tendency in eReuse circuits to accept devices (in particular, devices from public institutions, which generally already had more use hours and lower use value) without having assessed concrete demand. The consequence was that the pool of devices (CPR) was not balanced, with too many computers with low demand and not enough computers with high demand to meet supply.

Refurbished devices in the warehouse with low use value and without demand represent a sunk cost from preparation and a storage cost with no income. This leads us to the following conclusion: donating should imply delivering net value; otherwise, we should not call it donation. Rather, it would be barter, sale for compensation in exchange for services, disposal or delivery and collection of waste with reuse potential. In the latter cases, it is important for companies and government administrations to compensate for the negative externalities that may arise from the treatment of the equipment, such as economic compensation for data-erasure services.

That said, we analysed the economic feasibility of relying on device donations alone. We conclude that is hardly feasible and does not allow for a balancing of supply and demand. There is a need to combine donations (public or private) with other device sources to be able to plan investments or hiring of personnel.

Despite the consideration of other sources of supply, one solution for entities receiving donations is to cooperate in creating ecosystems as an eReuse circuit. This helps improve the ability to supply demand when that demand appears through short-scale electronics reconditioning or remanufacturing. This was the case during the peak demand in the initial months of the COVID-19 pandemic, when the eReuse circuit in Barcelona provided around 500 devices to citizens affected by the digital divide. For these related operations and due to the chaotic situation caused by COVID-19, cooperation amongst entities was key. Resolving the avalanche of requests required extensive logistical coordination amongst six reuse centres in Catalonia, at least 19 intermediaries (NGOs, municipalities, schools and public libraries), the contribution of a recycling company and logistical

42 https://publiccode.eu
43 González, XM., Rodríguez, M., & Pena-Boquete, Y. (n.d.). The social benefits of WEEE re-use schemes. A cost benefit analysis for PCs in Spain. https://doi.org/10.1016/j.wasman.2017.03.009
44 Kissling, R., Coughlan, D., Fitzpatrick, C., Boeni, H., Luepschen, C., Andrew, S., & Dickenson, J. (2013). Success factors and barriers in re-use of electrical and electronic equipment. Resources, Conservation and Recycling, 80(1), 21–31. https://doi.org/10.1016/J.RESCONREC.2013.07.009

and transport support. Final beneficiary support was needed in some cases, as well as maintenance for servitised pilots with Barcelona City Council.

Another important consideration is the pricing policy. A consumer will be indifferent to buying a new versus reused computer with similar features when the maximum price of the reused device is around €118.[45] Others have pointed out that five-year-old ICT devices, such as smartphones or laptops, must be free for the resulting total cost of ownership (TCO) to be lower than the TCO of new devices. 'From an economic point of view, such devices, even when they are acquired for free, never result in economic savings'.[46]

To conclude, in almost none of the articles presented was the type of software used in reuse estimations mentioned – whether cases were analysed using Linux or Windows, for example. Our goal for future work is to determine to what degree free software running on old computers without cost is an option for the final beneficiary. Use value, or functionality, must be preserved if we consider that, in the not-so-distant future, computers will become precious resources with more expensive scarce materials whose functionality will need to be carefully maintained in a more sustainable way. From this point of view, there may not be a hardware degradation but rather a software degradation that causes premature obsolescence, as software is an important factor that determines the longevity of equipment.[47]

ACTIVITIES TO REPLICATE CIRCUITS AND TEMPLATES

In the context of this project, we have explored replication in Spain with city councils in Madrid and Catalonia, as well as in other countries like the Netherlands, Luxembourg, the United Kingdom and Germany, with different degrees of progress.

Consolidating the replication of the practice in Madrid has given us experience and important insights about how to adapt tools to the specific contexts of each community, the need to simplify and automate processes to avoid time-consuming protocols, the importance of public support, the importance of working with public and private entities to raise awareness and the importance of communications and reporting. This experience shows that our practice and its supporting policy mechanisms can be replicated in other locations with similar contexts or under more controlled conditions in localities with lower development indices.

To do so, political support matters, as does public funding (in the form of subsidies or public procurement). Mapping both the reuse entities and the actors that can support and accompany the final beneficiaries is also key. In addition, it is necessary to assess the market; ensure that there is stable demand and supply of second-hand devices; define what is reusable and what is not (i.e. what should be recycled); be clear about what constitutes a donation (because it has net value) and compensate financially for what does not have value (because it has negative value, i.e. a net cost); and creatively promote behavioural change towards adoption of open-source software solutions to increase device longevity.

The trial and replication process starts with one local organisation close to the issue that understands the global interest in the circular economy and sees a viable local need for reused devices, including benefits for the local population as final beneficiaries and refurbishment jobs. Such an organisation can start with a one-off action to match the demand for computer devices with a single donation from a local public or private organisation or a campaign to collect computers from individual citizens.

Since 2003, we have initiated device circularity processes in Madrid, Huesca, Bilbao and Galicia (Spain), Rosario (Argentina) and Kenya (with Computer Aid), along with other initiatives that fall under the Association for Progressive Communications (APC.org). All are at different stages of maturity. In addition to continuing the processes in the aforementioned locations, during this project specifically we carried out the following activities to replicate our work in other European locations:

1. The Amsterdam City Council has a programme to distribute reused devices from the city for social impact. This activity is predetermined and planned to be implemented a few years from now (in a multi-year contract with a device supplier), but the contract is not yet public. We had productive email and phone interactions with a City Council representative and concluded that the only feasible collaboration would be learning from their lessons of the activities that were specifically developed during COVID-19

The municipality was very active during the COVID-19 lockdown, when it refurbished and recirculated 3,500 laptops for vulnerable people.[48] The document prepared to report the impact of this programme concludes that, should the initiative be repeated, the strategy of the Dutch capital should be 'hot

45 *See footnote 43*
46 *See footnote 30*
47 *Esther Jang, Matthew Johnson, Edward Burnell, and Kurtis Heimerl. 2017. Unplanned Obsolescence: Hardware and Software After Collapse. In Proceedings of the 2017 Workshop on Computing Within Limits (LIMITS '17). Association for Computing Machinery, New York, NY, USA, 93–101. DOI:https://doi.org/10.1145/3080556.3080566*
48 *In Dutch language: https://openresearch.amsterdam/image/2021/1/7/evaluatie_iedereen_verbonden_amsterdam_umc.pdf*

donation': the term describes cases in which the final beneficiaries receive devices through intermediaries, such as NGOs or other small non-profit institutions. Although only 30% of the 68 organisations that brokered the initiative offered individual and group support to the end-beneficiaries, this proved to be key to actually ensure these devices had an impact.

2. Allemaal-digitaal (All Digital)[49] is a public–private initiative in the Netherlands that has refurbished around 6,000 devices in the last year. We had productive email and video interactions with representatives of NL Digital[50] and Recover-e[51] (parts of the initiative). They showed interest in using legal templates to improve return rates of the devices ceded to beneficiaries, in opening the donations they receive to public institutions and in using our technology to reconcile privacy and transparency in accountability. In fact, their tools allow for certified data wipes, device analysis and inventory via CRM, but they are not open source and do not have a method for auditing all operations. Although there was interest, they were already overloaded with their programme, and a longer time span is needed to develop a collaboration.

3. Digital Inclusion in Luxembourg[52] works with refugees and was interested in high-quality reports to attract public donations. They sometimes rely on the purchase of decommissioned laptops to meet demand, particularly during the pandemic. They install Windows on these devices because 'there is not a Linux culture'. We had productive interactions via email and video to discuss shared experiences and interests, but the programme is run by volunteers, and influencing public policy was not a key goal of their initiative.

4. Computer Aid,[53] located in the United Kingdom and Kenya, refurbishes more than 6,000 devices per year in Manchester. We had interactions before this project, but this project led to productive email and video interactions with several members to explore collaboration. Public policy is not a key element of Computer Aid's initiative, as most computers received come from private donors. However, we found very strong alignment in several activities, and we are discussing how to integrate our software in a way that enables Computer Aid to increase the efficiency and transparency of its operations. Computer Aid's minimum acceptable computational capacity for devices is i3 processors, 4 GB RAM and 500 MB hard disks. After years of attempting to use Linux, user rejection has led them to install Windows by default.

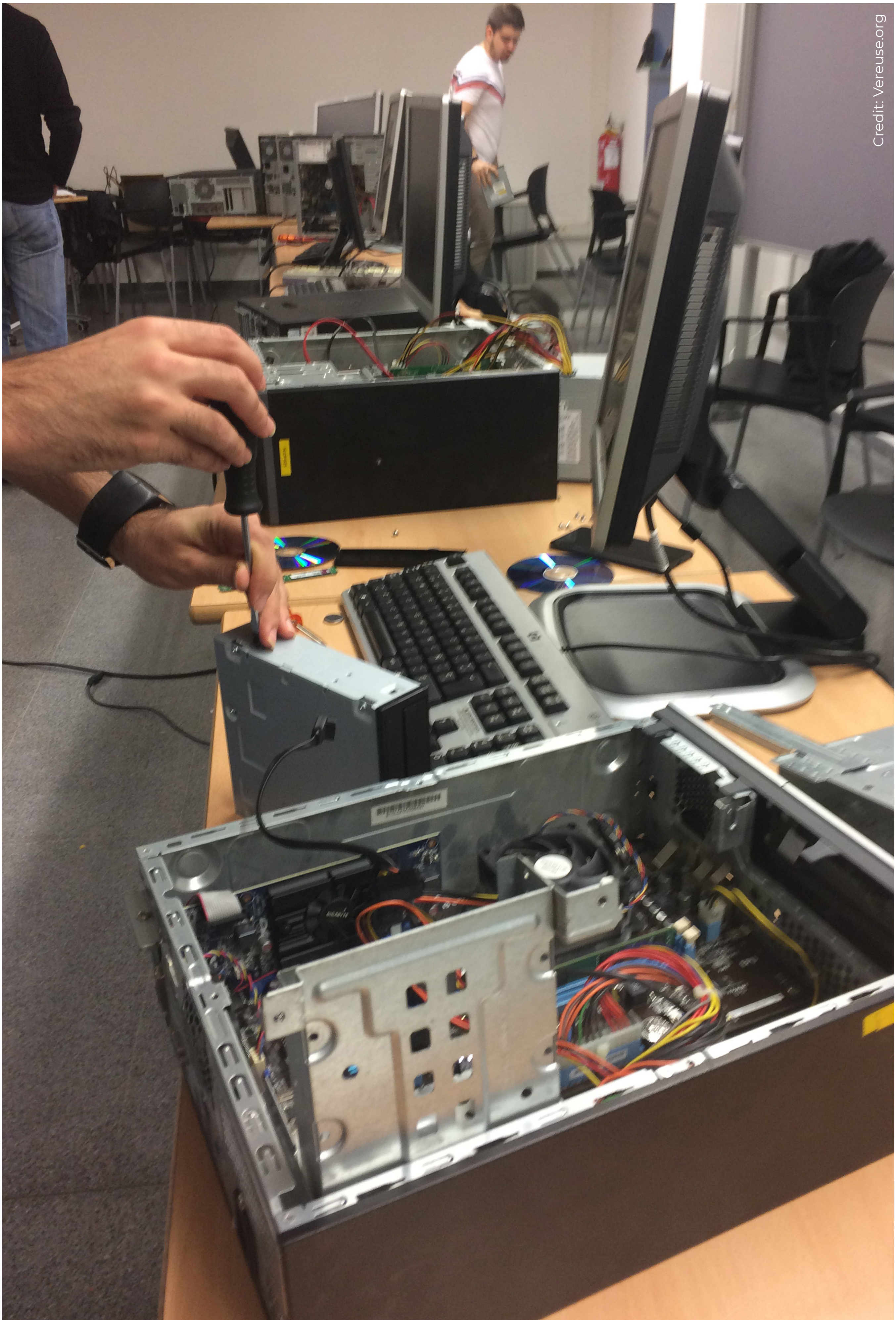
Apart from these, we highlight three initiatives that developed or evolved as part of this project because of their importance at the public policy level:

5. Sant Boi (Catalunya, Spain) has adopted and is using our legal templates. The city council is refurbishing its decommissioned computers for donation to disconnected local students. They are using a set of technological tools that we are developing that generate reliable and certifiable information through a permissioned blockchain. We had interactions before this project, but this project has led to these additional activities.

6. At **Getafe City Council (Madrid)**, La Kalle-ReutilizaK (part of the eReuse initiative in Madrid) and Lyma (the municipal waste company) have signed an agreement to create and coordinate a circuit for the reuse of electronic devices that will be made available to the general public, NGOs, schools and institutions at fair prices. This circuit is fed by devices valid for reuse that are received at clean points in the municipality and through donations from companies and individuals. We had interactions before this project through our partner in Madrid, but this project has led to these additional activities.

7. At **Kiel City Council (Germany),** we have initiated discussions on supporting the city of Kiel in its capacity to build a local circuit, as well as providing training on our open-source software, infrastructure and impact accounting. Kiel is one of the first municipalities to become a zero-waste city and is pushing circular processes more than other German cities. If Kiel is to replicate a circuit, the scheme would rely on a local zero-waste organisation that would have agreements with the city council, similar to Barcelona. We learned about their activities in June through several emails and two calls that seem promising for the future.

49 *In Dutch language: https://www.allemaal-digitaal.nl/over-allemaal-digitaal/*
50 *http://nldigital.nl*
51 *http://recover-e.nl*
52 *https://www.digital-inclusion.lu*
53 *https://www.computeraid.org*



Credit: Vereuse.org

LEGAL CLAUSES DEVELOPED DURING PROJECT

Our contracts and templates allow the following:

1. **To transfer ownership or possession of devices** with different types of clauses related to property rights.[54] For the time being, we have defined three types of transfer of ownership in our agreements. Changes of ownership are recorded in the eReuse software.

   1.1 The first – which is followed by the Barcelona City Council, other public institutions such as the Catalonian Waste Agency and private companies in Spain – **formalises an agreement with an umbrella organisation** that fairly distributes decommissioned computers amongst the entities of the territory. The criteria considers those actors that have proven to be transparent and that can directly seek demand or rely on other entities to do so. The property never belongs to the end user but rather to the entity that has acted as an umbrella (only the right of use is transferred to the final beneficiary through a commodatum contract). The defined clauses prevent the umbrella entity from charging for this activity (as a device comes from a donation), but the reconditioning entities are allowed to charge for the cost of the reconditioning services needed.

   1.2 In the municipality of Sant Boi, the **municipal government maintains ownership of their devices** for the entire lifecycle, until recycling, refurbishes them internally and distributes them amongst populations affected by digital inequality. In the use case that we have jointly developed, the beneficiaries were public schools in the municipality, where school principals identify which students need a device and provide them with a municipal one. In the long run, however, and to expand the project, the municipality is considering outsourcing the refurbishment service to a local reuse centre. In this case, there is no intermediary entity.

   1.3 Another case in which there is no intermediary entity is Kiel, where, according to preliminary discussions, the municipality is more interested in **transferring ownership to a reuse entity**.

2. **To regulate what types of electronic devices can be donated** based on what the circuit considers to have a **positive value**. This calculation is the result of: (a) evaluation of the demand for equipment to be donated, (b) the potential funded public and private projects with firm demand, (c) the costs and obligations required for the final beneficiary and (d) the services requested as part of the donation (e.g. collection, inventory, sorting, deletion, reinstallation, testing, reconditioning, cleaning, memory expansion).

3. **To regulate circular and social impacts by specifying end-user target segments.** In this regard, and as we have mentioned, municipalities can seek various ways to prioritise populations affected by the digital divide and, to avoid overly strict constraints in this aspect, to allow the general public access to devices. For example, the clause can reserve a certain percentage of donations for a specific target and leave the rest for the general public. Alternatively, the municipality might stipulate a period of time (e.g. three months) after which the devices can be offered to the general population if no demand is found amongst citizens affected by the digital divide.

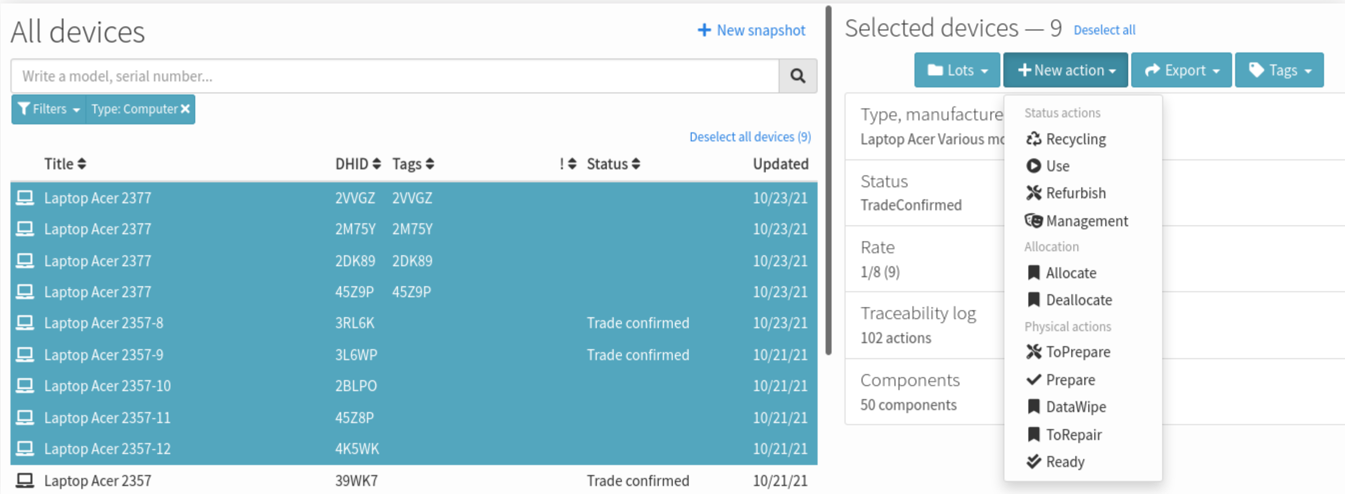
4. **To identify target refurbishing organisations with proven impact accounting that are able to distribute devices transparently and efficiently.** Mitigating the risks expected by potential public or private donors, such as uncertainty caused by data wipes or the quality of refurbishment, is an important issue. In this sense, reuse centres in eReuse circuits can accredit through both established protocols and eReuse accreditations. We have designed different types of accreditations for reuse centres. Whilst these are not within the scope of this project, broadly speaking, we use the following to prove reuse quality: (a) data are automatically and securely generated after running a software application on the device to be reconditioned, with the resulting data published directly to a device inventory web service; (b) it is infeasible to modify data manually; and (c) the (anonymised) data are open access in that they are accessible via a web link (that does not require access credentials such as username and password). In addition, data should be accessible via a QR code attached to the device that links to the device's website. An example is available at the following link: https://api.usody.com/usody/devices/2DBZ9

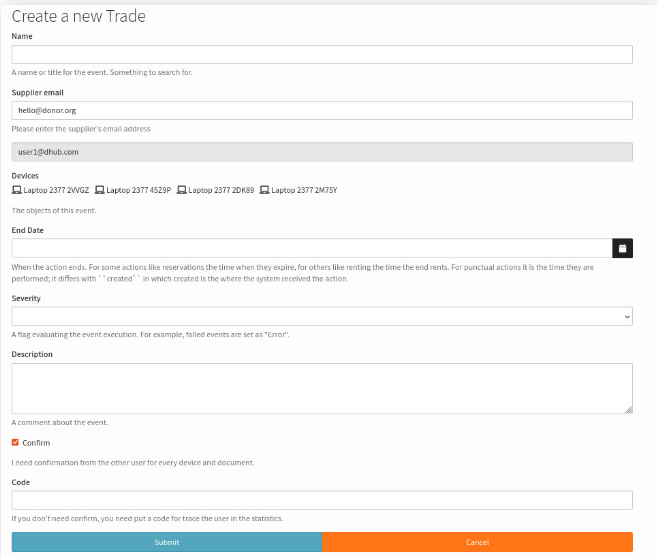
54 Schlager, E., & Ostrom, E. (1992). Property-Rights Regimes and Natural Resources: A Conceptual Analysis. Land Economics, 68(3), 249–262. https://doi.org/10.2307/3146375

BR8N9

This web page shows potential users the specifications of reused devices, their main components and their reuse potential rate, which is calculated according to an algorithm we designed. The remanufacturing process is also shown: performance tests, software and versions thereof.

5. **To obtain impact data and circularity reports on the traceability of devices over multiple owners and possessors without affecting privacy.** A reuse centre must state whether each device has been recycled or reused. In the latter case, they must also report the price paid by the final used entity. To trace a device, we must be able to generate a globally unique and self-generating identifier, called the device ID. This can be part of a digital device passport and is generated according to invariable device information, such as the brand, model, serial number and identifier of the network card, which are recorded with our software tools. Along with other technical aspects, the software allows the reuse centre to issue reuse and recycling certificates, as shown in the images below.





6. **To ensure data integrity in order to provide feedback to donors regarding redistribution and certificates on the circular impact of the transition** (e.g. CO2 avoided, hours of extended usage, product segment). Reuse centres share with eReuse the data necessary to measure the useful life of devices, such as potential useful life, real useful life, operating hours and powered-up hours. These data allow reuse centres to improve the device filtering process so they can better identify items with high reuse potential. This information is aggregated and published to help consumers and public or private institutions purchase devices according to the durability metrics we have registered.

7. **To ensure process audits through a distributed ledger (blockchain).** For years, eReuse has offered a set of tools that automate the process of secure collection and traceability monitoring in digital device management. These data are transferred to a digital logbook using blockchain technology to ensure their immutability (inability to change the past) and verifiability (ability to confirm that a fact is supported by an attestation at a certain moment, which is only possible with certain data, but without including those data – only a summary or signature).

8. **Regulate the public procurement of computing services to equip, overhaul, reuse and maintain computer equipment.** Public administrations might prefer a holistic computing solution that offers a number of computing seats instead of the ownership of certain devices. This is the case in public computing facilities and computing classrooms for schools equipped with a number of computer devices and internet connections with agreed-upon characteristics maintained by a third party under a service-level agreement. Since the end of 2018, we have maintained two classrooms in community centres (Casals de Barri) together with Barcelona Activa, and we are working on replicating the practice within the municipality.

FINDINGS AND OUTPUTS

Through taking a critical perspective on eReuse, and based on our accumulated experience in the last few years reusing computers from public administrations and companies, we have identified some other key points that can aid in providing computing services that genuinely satisfy and substitute the demand for new devices at affordable prices for excluded and not-excluded people, ensuring positive social, economic and environmental impacts.

On the one hand, COVID-19, as a related effect to human pressure to the environment and thus related to climate change, is the subclinical diagnosis of the enormous problems to come if the planet is not urgently decarbonised. On the other hand, the pandemic is a prelude to a series of proposals that could provide a response to as-yet unresolved environmental and social challenges, such as digital inequality. The complexity of reconciling these challenges is enormous, and there is also a separation between time and space for solving the problems. Thus, there is an asymmetry in economic incentives for COVID-19 versus climate change: both are potentially catastrophic but operate at different time scales, such that the perception of actual and potential risks seems reversed (as are, consequently, the resources allocated to each).

As an example of how the fight against climate change and the digital divide operate at different scales, we present the case of the Generalitat de Catalunya. On 15 May 2020, when the Spanish government declared the first state of emergency, 15% of Catalonian households did not have any type of computer at home (tablet, laptop or desktop).[55] The unresolved issue of digital inequality was thus brought to the fore. To alleviate the need for infrastructure for the approximately 300,000 families with children in home-schooling, and following the needs assessment carried out with school directors, the Generalitat of Catalunya resorted to the old, well-known linear economy approach with a service contract valued at €82 million. However, the solution that initially seemed easy turned out not to be. By 18 January 2021 – eight months after the declaration of a state of emergency – only 5% of awarded computers had arrived. It might have been possible to meet unmet demand with financial public support for reuse programmes, utilising this strategy to combat both problems (i.e. climate change and digital inequality).

55 *National Statistics Institute of Spain. 2019. Encuesta sobre Equipamiento y Uso de Tecnologías de Información y Comunicación en los hogares 2019. National Statistics Institute of Spain. Retrieved Abril 1, 2021 from* https://www.ine.es/up/jeFtuUrziA

Credit: Giovanni Gagliardi via Upsplash

The complex relationship amongst the four actors (state, market, families and commons) gives rise to many paradoxes, which sometimes does not allow for a rationalistic simplification of the process through a simplification of the actors involved. Adaptability and adaptation to the context of eReuse circuits requires frequent and agile experimentation and self-evaluation, which involves testing and verifying alternative models and failing and changing quickly.

We can structure our conclusions as follows:

More important in the output (demand) than in the input (donation)

Although, by donating their equipment, municipalities encourage other administrations or private companies to follow suit, the importance of public administrations lies not so much in their input (donation) as in their output (demand). In all the studied cases in Europe, public administrations are more efficient in using their devices than private companies, achieving eight to nine years of use, according to our semi structured interviews. Thus, they may wonder if it is actually a good idea to reuse devices. The calculator we developed, along with the references mentioned above, indicates that it is environmentally advantageous to reuse a computer. However, above a certain computational power (Intel Core 3), there are demand problems that may require very creative social, environmental and economic solutions, such as adapting hardware to software, rather than the other way around; accompanying the beneficiaries in learning and maintaining basic skills, if necessary; and obtaining public or private funding.

Public procurement and regulatory instruments

Public administrations can create markets for circular products and services through public procurement, which is a very powerful instrument. The measures that municipalities can adopt include regulatory and economic instruments.[56] Amongst regulatory instruments, there are actions that we have already mentioned in the section on how to replicate circuits: boosting social capital, monitoring impact, setting social and environmental objectives and ensuring long-term thinking and collaboration. These are soft measures to achieve socially desirable outcomes and ensure sustainable and inclusive development. All of this facilitates ongoing circular activities but is not strongly related to job generation.

Public procurement and economic instruments

Economic instruments, on the other hand, do lead to the creation of core circular jobs (e.g. remanufacturers, enablers, digital jobs) as well as indirect jobs (those that provide services to primary circular activities and create other supporting activities). Some of these economic instruments include subsidies to overcome financing barriers, public procurement and second-hand consumption subsidies for direct buying of second-hand computers.

How to create an economically sustainable CPR?

Access to a constant flow of good devices was a clear need in all experiences analysed. We conclude that community CPRs and circuit activities should be nourished by devices donated by private companies (or sources other than donations) and that donations from public administrations should be limited to a minimum of responsible public procurement or other instruments. Moreover, having a business model that includes only the population in need as a target audience is hardly sustainable or viable in the long term, as previously stated. Thus, it is important to consider the need to break the reuse–poverty paradigm in order to make real progress in the decarbonisation of the planet. It is important for public administrations to take this into account so that they do not overly restrict the final public in the agreements.

Before accepting devices, it is necessary to carry out a study on demand. In this regard, it is not advisable to set expectations too high with regard to reuse through agreements that leave little room for recycling. Before proceeding to refurbishment, it is important to ask whether there exists anyone willing to pay for a refurbished device. In this sense, public policies should allow for decommissioned devices to be reused or recycled when there is no value in the donation, with appropriate economic compensation for services such as collection, transport, data wiping and destruction of electrical and electronic equipment waste.

56 *See footnote 5*

Reconciling activities with initiatives that can generate dumping

Dumping, pricing and compensation initiatives sponsored by public entities or that are volunteer-driven tend to offer devices at no acquisition cost. This creates an imbalance in comparison with social enterprises, where employees prepare refurbished devices that need to cover their professional costs. One solution is to reach agreements with these initiatives to segment intermediary entities (NGOs) that can pay for those who genuinely cannot pay (e.g. analysing their income-generating activities from annual activity reports). Another option is (when the target audience is the same) to raise funds to complement volunteer work with paid-for refurbished devices prepared by social enterprises. Moreover, when the general population is the beneficiary, the pricing strategy for donated devices prepared for reuse by social enterprises need not undercut (economic dumping) existing second-hand–sector market prices. This enables the generation of an economic margin and more jobs.

Substitutability as a key concept

Sustainable development relies on the three pillars of economy, protection of the planet and social justice. In the public discourse, the position of the environment may prevail over or forget the social dimension. In the case of computer reuse, the social prevails over the environmental, since the former is a *sine qua non* condition of the latter. That is, substitutability is a key concept for both social and environmental impact.

Change in human behaviour

From a critical perspective and based on our experience, training in digitisation and public awareness is essential for technological appropriation, an important concept that helps reduce the discarding of devices due to preventable causes such as software degradation. We believe that these concepts are connected to impact generation whilst preventing rebound effects caused by the premature discarding of devices due to lack of familiarity with Linux. The attempt to work with Linux and the switch to Windows as a consequence of the lack of a 'Linux culture' was also a constant. This human behaviour barrier limits the reuse of devices with low computational power and the longevity of devices in general.

To conclude, we have presented a solution that helps public policy connect knowledge about reverse supply chains to future policies to become more tangible and transparent.[57] Overall, this framework attempts to reconcile all interests and to redefine relationships whilst fostering boundary conditions for the circular economy to achieve its full potential.

The circular economy is strongly embedded in the local economy, as it has the ability to support and strengthen networks and the sharing economy, close resource loops and create logistical schemes for device return. Ways to be transparent include conveying covenants and using technology to capture details about devices across their lifespans, certifying impact and showing the positive externalities of reuse (e.g. environmental savings, social inclusion, local jobs created). The role of coordinating organisations driven by technology, as well as accountability reporting, is one of the key points of the agreements.

57 *Williams, E., Kahhat, R., Allenby, B., Kavazanjian, E., Kim, J., & Xu, M. (2008). Environmental, Social, and Economic Implications of Global Reuse and Recycling of Personal Computers. Environmental Science and Technology, 42(17), 6446–6454.* https://doi.org/10.1021/ES702255Z

To conclude, we set out the axes that we believe are necessary to promote the circular economy based on feedback from the municipalities and our experience. We summarise how policymakers can influence the acquisition, use, reuse and recycling of electronic devices. The following are **potential benefits and lines of action for public policy to lead by example and create an environment that promotes and supports circular practices.**

A. SUSTAINABLE PUBLIC PROCUREMENT

Regarding digital devices, sustainable public procurement refers to the volume of computing devices and related components (e.g. printers, displays, network devices) purchased by governments and state-owned enterprises. It usually includes not only supply but also deployment and installation services, as well as initial warranties. It may include maintenance during use in an organisation as well as disposal at end of use after several years, which may not be the end of life for the device, presenting an opportunity for further use or final recycling.

Public institutions, through purchasing consortiums, prepare volume (public) procurement contracts of ICT solutions that can include clauses to ensure compliance with environmental (e.g. eco-design, life-cycle assessment,[58] quality recycling), labour, safety and quality standards in the supply chains of the ICT hardware goods they purchase.[59] These can include not only performing due diligence regarding suppliers' compliance with a set of requirements but also requirements related to take-backs, further reuse and responsibility for e-waste through certification and cost supplementing for high-quality recycling that maximises resource recovery and minimises disposal and negative effects. Purchasing consortiums, which group the volume of devices required by several public institutions in an area, can improve quality, cost efficiency and effectiveness in procurement processes and can verify the compliance of the results.

Sustainable procurement means that public institutions obtain only those goods and services that have been produced under humane working conditions and do not have any avoidable harmful effects on the environment. For example, it could be considered whether the Core Conventions of the International Labour Organisation[60] are being met in the production process or whether energy efficiency demands are met. The purchasing power of major public customers, as a result of their large contract volumes, means that public tenders have great economic weight and therefore great leverage when it comes to setting sustainability standards. Their ability to influence manufacturers with regard to the devices they design and manufacture in turn has a global effect on all devices for any other buyer, including citizens everywhere. In this way, procurement allows public buyers to empower non-profit organisations, such as Electronics Watch,[61] to exercise the collective power of volume procurement to monitor and help enforce standards for sustainable manufacturing, detect problems that workers do not usually report, remedy problems in a timely manner and address systemic issues over time.

The Global Electronics Council[62] and TCO-certified[63] organisations provide independent verification and certification that products and procurement processes meet comprehensive environmental and social criteria throughout the lifecycle. Both qualify as ISO 14024 Type 1 compliant ecolabels: 'a voluntary, multiple-criteria based, third party program that awards a license that authorizes the use of environmental labels on products indicating overall environmental preferability of a product within a particular product category based on life cycle considerations'.[64]

B. CIRCULAR USE, REPAIR AND REUSE

This is the use phase. Devices serve a generic or specific purpose, depending on whether they are intended for personal or organisational use. Their correct operation depends on their software. This software evolves over time to keep the device operational (e.g. bug and security fixes). Devices come with a warranty to correct manufacturing defects and, later, maintenance problems during the expected lifespan. The hardware and software of some devices can be upgraded, modified and repaired to adapt to evolving needs.

58 Andrae, A. S. G. (2016). Life-cycle assessment of consumer electronics: A review of methodological approaches. IEEE Consumer Electronics Magazine, 5(1), 51–60. https://doi.org/10.1109/MCE.2015.2484639
59 Electronics Watch, Public Buyer Toolkit, 2020, https://electronicswatch.org/en/public-buyer-toolkit_2548345
60 https://www.ilo.org/global/standards/introduction-to-international-labour-standards/conventions-and-recommendations/lang--en/index.htm
61 Contracting for change: https://electronicswatch.org/en/contracting-for-change_2548241
62 https://globalelectronicscouncil.org/epeat-registry/
63 https://tcocertified.com/tco-certified/
64 https://www.iso.org/obp/ui#iso:std:iso:14024:ed-2:v1:en summarized in https://tcocertified.com/iso-14024/

In private organisations, computer devices are usually part of an inventory, with associated insurance, maintenance and accounting. Devices depreciate over time: their accounting value decreases as they are used and wear out, and their cost is spread over time (e.g. three to five years). However, depreciation in accountancy may be stimulated by tax benefits. It may occur too quickly and go down to €0, even if devices are still usable and under warranty or maintenance. If we depreciate our products, we might treat them as waste with no perceived market value, contrary to reality in many cases.

A device may be no longer suitable for a task because the task requires greater computing capabilities or because the device's performance has degraded over time due to wear. Sometimes, this is due to software: if the system software is not maintained, bugs and unpatched security problems make a device unreliable for normal use. The end of one use cycle, when a device is no longer fit for its initial purpose but still has use value, may create an opportunity for internal reuse for another, less demanding purpose in the same organisation.

When a device does not meet an organisation's needs, is too costly to be maintained or cannot be maintained or repaired by a supplier or repairer, that marks the end of use in that organisation, and the device can be disposed of. However, disposed devices in one organisation can be a resource for other users through refurbishment to allow device reuse, scavenging parts for reuse or offering materials reuse (urban mining) through recycling, thereby avoiding highly polluting burning or landfilling.

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

End of use. Once the initial owner no longer needs a device, the device storage must be data wiped and restored to the default 'factory' settings for reasons of privacy and confidentiality. There are three subsequent steps: (1) the device is sent back to the manufacturer for remanufacturing, in case some parts can be reused in new devices; (2) the device is donated or sold directly to a new user or to an organisation that can refurbish it, which may enhance it (via upcycling) to prepare it for a new use (and user); and (3) the device is collected by a recycler for disassembly, recovery of resources (materials, energy, parts) and disposal of e-waste. These operations can be driven by economic, environmental or social motivations: obtaining money from the sale if there is a buyer (exchange value), ensuring minimal environmental impact (usually through good-quality recycling) or providing computing services to the community for corporate social responsibility, such as non-profits, libraries or vulnerable citizens.

In a complete life cycle analysis, we can see devices from different perspectives as a long-lasting circular good. In terms of rights and responsibilities, we are concerned about who has the right to use devices and the computing services that devices provide. Regarding ownership, users may be owners or just custodians (accommodate, or loan for use – similar to a book in a library – or even a servitised contract for a computer unit 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 perspective, devices can be viewed from a planetary or footprint perspective: whether materials are scarce or abundant, what energy use and emissions are involved, greenhouse gas emissions and equivalence and e-waste potential.

C. CIRCULAR POST-USE

After one or several use phases, the device is no longer usable for any purpose, indicating its end of life. At this point, it is downcycled into parts, raw materials or e-waste: shredded, separated and treated as disposal for landfilling, energy recovery or recycling. Recyclers may be for-profit or non-profit businesses but cannot work at a loss. They are paid by the manufacturer (the extended producer responsibility),[65] the person or organisation bringing the devices or a buyer of the resulting output. This payment determines the quality and threshold of the recycling. Some processes may be too costly and specialised to apply.

E-waste is a symptom of the overall problem of digital devices' environmental impact, which is aggravated by dumping, early recycling and bad design, amongst other factors. There is the temptation and practice to export end-of-life devices (e-waste) to less developed countries, where they are declared as usable second-hand devices, as this can be cheaper than processing them locally. Although the Basel convention[66] forbids the exporting of e-waste, we see news about containers full of waste being returned to developed and less developed countries – especially those without e-waste legislation of their own – and suffering from nearly or non-usable devices in practice, with hazardous materials being dumped and affecting the health of inhabitants.

65 https://en.wikipedia.org/wiki/Extended_producer_responsibility
66 Basel Convention, on the control of transboundary movements of hazardous wastes and their disposal 1989, http://www.basel.int

E-waste is one of the fastest growing waste streams. It is commonly discarded together with general waste, leading to pollution of groundwater and other natural systems and creating serious health impacts for local communities. Countries in the global North continue to illegally export hazardous e-waste to countries in the global South despite treaties such as the Basel convention.[67] In middle- and low-income countries, informal workers sort and process e-waste for valuable minerals and resources, causing severe health effects for them and their children and polluting communities' air, water and land.

Good recycling can create jobs whilst reducing the human and environmental impact of the leakage of toxic materials, which can expose workers and other citizens to hazardous substances, and preventing depletion of natural resources, particularly scarce materials. Different disposal processes have different costs and impacts, which have already been discussed in a diverse comprehensive analysis.[68]

Processing ends when the costs for the processor organisation outweigh the value of the extracted resources. Locality (i.e. processing e-waste near its source) may reduce costs in some cases. Another method may be to aggregate larger volumes in order to take advantage of more sophisticated processes to efficiently extract certain valuable materials and reduce the disposed fraction. Research and experimentation regarding more cost-effective separation and extraction practices can have positive impacts.

D. CIRCULAR BUSINESS MODELS

Social enterprises that collect, repair and sell devices provide employment opportunities for individuals interested in this work. There are opportunities to create economically sustainable organisations that follow circular business models, such as pay-per-use, renting, sell-and-buy-back and leasing. The following figure defines and compares these models. Social enterprises can be driven by both environmental and social objectives, keeping economic objectives (profit maximisation) in a secondary role.

Traceability and verifiability.

Breaking the barriers to circularity requires efficient data, tools and services to optimise each step and ensure the traceability of devices managed as a common resource system. Gathering details as digital (linked) data about the various milestones of a device along its use lifespan, from acquisition (ideally tracing back to manufacturing) through multiple use phases until (and ideally including) recycling allows us to assess and even verify – as opposed to guessing – the social (use), economic (business) and environmental (footprint) impacts of digital devices. These details can form the basis for organisational impact assessments as well as public incentives and regulations to comply with sustainability goals, particularly as governments attempt to implement commitments to climate change mitigation.

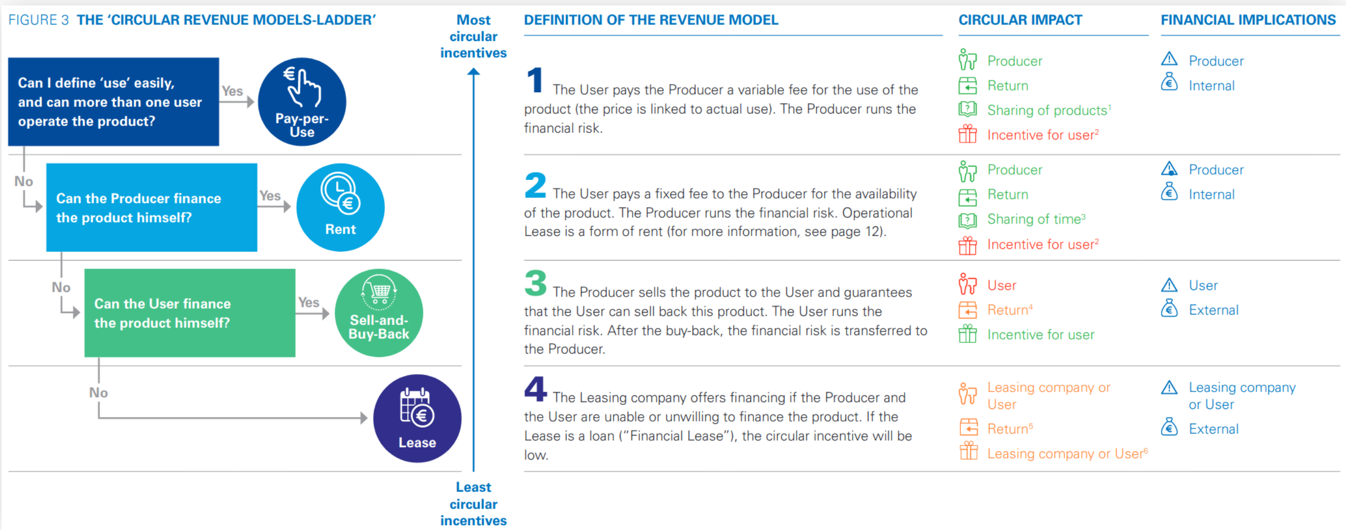


Figure: Circular revenue models ladder. Source: Circular revenue models: see footnote 28

67 https://www.giswatch.org/thematic-report/sustainability-e-waste/tackling-e-waste

68 Viviana M. Ambrosi (2018), Successful electronic waste management initiatives, International Telecommunication Union (ITU) Least Developed Countries, Small Island Developing States and Emergency Telecommunications Division, https://www.itu.int/en/ITU-D/Climate-Change/Documents/2018/Successful-electronic-waste-management-initiatives.pdf

Servitisation:

from device ownership to custody. We own devices mainly for the purposes and benefits of computing, not for company as pets. If what we really want is computing services, not ownership of our devices, we should consider servitisation: a focus on the right to use, not 'ownership'. To maximise circularity, we can view devices as collective property (commons), or at least as a collective responsibility, that circulates amongst users until final recycling. As we have explained above, we are running servitisation projects with public administrations that have opted for responsible and green public procurement of second-hand devices to equip public facilities in vulnerable neighbourhoods in Barcelona. The service is associated with infrastructure setup and maintenance and rental – not acquisition – of equipment.

E. CIRCULAR CONSUMPTION MODELS AMONGST CITIZENS

It is necessary to mobilise and promote the circularity concept amongst families and beneficiaries who consume potentially circular products through business support schemes, the promotion of green and circular entrepreneurship, and communication and awareness raising.

The best way to help the environment is to reduce consumption. Before purchasing a device, users should ask whether doing so is necessary to achieve their required functionalities and whether it is possible to consider other options, such as changing their operating system to extend the life of their current device. If new devices need to be purchased, the option of certified second-hand markets should be prioritised. If second-hand devices are still not sufficient, users should choose to buy something durable.

The eReuse field study collects and publishes open data about desktop and laptop devices beyond first use (i.e. reused).[69] In this reuse practice, nearly all devices are refurbished with reused components, except for new batteries and storage devices when they raise signals of failure (SMART monitoring).[70] The dataset shows durability per manufacturer (90th percentile amongst devices from the same manufacturer) in terms of total use hours, up to 46,000 (5.3 years) and a maximum of 65,000 hours (7.5 years), consistent with other studies.[71] Public datasets[72] show that reuse can contribute to an approximate duplication of the lifespan of personal computers.

This is particularly relevant as an enabler of a servitised model, wherein organisations, rather than owning devices, pay an annual service fee for a number of operational computer units with a certain performance level and data storage in the network, wherein faulty computers can be easily replaced with in-situ spare ones. The device owner is the service provider, which builds or selects the most resilient and durable devices for its own benefit.[73]

Furthermore, it is important to second the requests of the European and US repair campaigns:[74]

Good design:

Products should be designed not only to perform but also to last and 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:

Repairs should be accessible, affordable and mainstream. This means that repairing a product should not cost more than buying a new one. Legal barriers should not prevent individuals, independent repairers or 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 whether their products are built to be repaired or destined to be disposable when they break. Information on product repairability should be made available to citizens at the point of purchase as well as to repairers.

69 https://dsg.ac.upc.edu/ereuse-dataset
70 https://en.wikipedia.org/wiki/S.M.A.R.T.
71 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
72 See footnote 69
73 The analysis of a mobile phone as a service: https://breakthrough.unglobalcompact.org/briefs/fairphone-as-a-service/
74 https://repair.eu in Europe, and https://repair.org in the USA.

From these demands, the demand for the fulfilment of rights is as follows:

Right-to-repair campaigns:

This relates to government legislation intended to give consumers the ability to repair and modify their own consumer electronic devices, where otherwise the manufacturer of such devices requires the consumer to use only the manufacturer's offered services or buy a new device. Repair, defined as returning a device to working condition, allows use to be resumed by the same or another person (reuse).

The right to use a device:

If we consider devices as valuable for their computing resources, then we should focus on the right to use a device, not the right to ownership. Maximising circularity asks us to see devices as collective property that circulates amongst users until it is ultimately recycled. Projects that work towards the circularity of digital devices also aim to reduce social inequality. Low-cost computing has become essential in overcoming barriers to internet access. Reuse allows us to find and serve less demanding users and use requirements when previous-generation devices suffice. This has been clearly seen in the COVID-19 crisis, where many school children could benefit from second-hand computers for home-schooling that are decommissioned devices from public and private offices.

This report was created by Nesta for NGI Forward, part of the Next Generation Internet initiative, a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°825652

Websites:
https://www.ngi.eu
https://research.ngi.eu

Twitter
https://twitter.com/ngi4eu
https://twitter.com/ngiforward