European
Commission

ICT TASK FORCE STUDY

Task 2 Consolidation of the Scope, Definitions and Product Groups covered by this study

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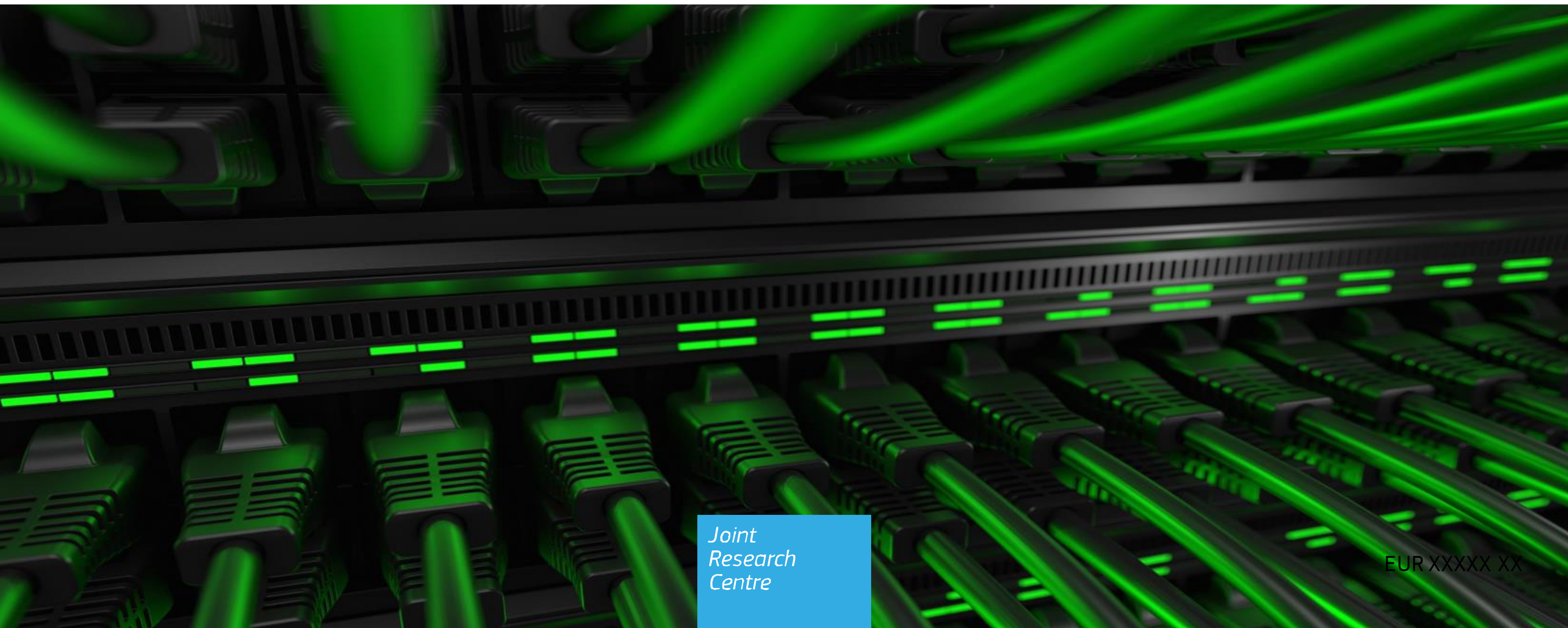

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1 Introduction

Information and Communication Technologies (ICT) play an increasingly important role in society and the daily lives of European citizens. This has been clearly demonstrated by the critical importance of ICT devices and infrastructure during the Covid-19 pandemic, which allowed people to work and study from home, keep in touch with family and friends and stay informed. Indeed, according to the IEA, global internet traffic surged by almost 40% between February and mid-April 2020, driven by growth in video streaming, video conferencing, online gaming, and social networking and following a general growth in demand for digital services over the past decade[1].

At the same time, this increased demand does not come without costs. In the pursuit to address the environmental challenges that society is facing, the ICT sector can be analysed from a dual perspective: from one side as crucial in supporting and enabling sustainability strategies, and from the other side as responsible for relevant impacts related to energy and material use in its lifecycle.

In order to provide a basis for policy-making to improve the sustainability of ICT, the direct and indirect environmental impacts from ICT need to be evaluated from a perspective of an overall system, considering the interactions between end-users, devices, telecommunication network and data storage and processing by edge computing/data centres.

Making a reliable estimate of the energy and material savings potential in ICT is a particularly challenging task due to aspects like the uncertainty about future market developments, the increased connectivity and multi-functionality of products, the advent of smart appliances and the behavioural changes in our society.

In 2016, the Commission announced, in the context of the Ecodesign Working Plan, a Task Force on ICT products, composed by experts from different Directorates, aiming to explore how ICT products could best be addressed under the Ecodesign Directive and the Energy Labelling Regulation.

In this context, the Joint Research Centre is supporting the activities of the Task Force by providing a comprehensive and dynamic analysis of the ICT sector. In particular, this work is being developed for the European Commission's Directorate General for Energy.

Based on material and energy efficiency improvement potentials identified, and considering user behaviour and lifecycle costing aspects, JRC will provide policy recommendations on the inclusion of Ecodesign Criteria, but also on complementary policy tools to improve the sustainability of ICT products and systems.

[1] International Energy Agency (2020), Data Centres and Data Transmission Networks, https://www.iea.org/reports/data-centres-and-data-transmission-networks

2 What is ICT? Definition and scope

Information and Communication Technology is defined by ISO (ISO, 2008) as "technology for gathering, storing, retrieving, processing, analysing and transmitting information".

A definition of ICT products is provided by OECD (OECD, 2011): "ICT products must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display".

In VHK and Viegand Maagøe (2020), "ICT products" are understood to be products from both the information technology and the communication technology sectors.

The main characteristic these product groups share is that they (increasingly) allow communication between devices through the internet (including home networks using other protocols but are ultimately connected to the internet). ICT products can enable the communication at end-use level, by providing telecommunication network infrastructure or by providing data storage and processing in data centres / cloud. These represent the main elements and relationships of an information and communications technology (ICT) system (see Figure 1).

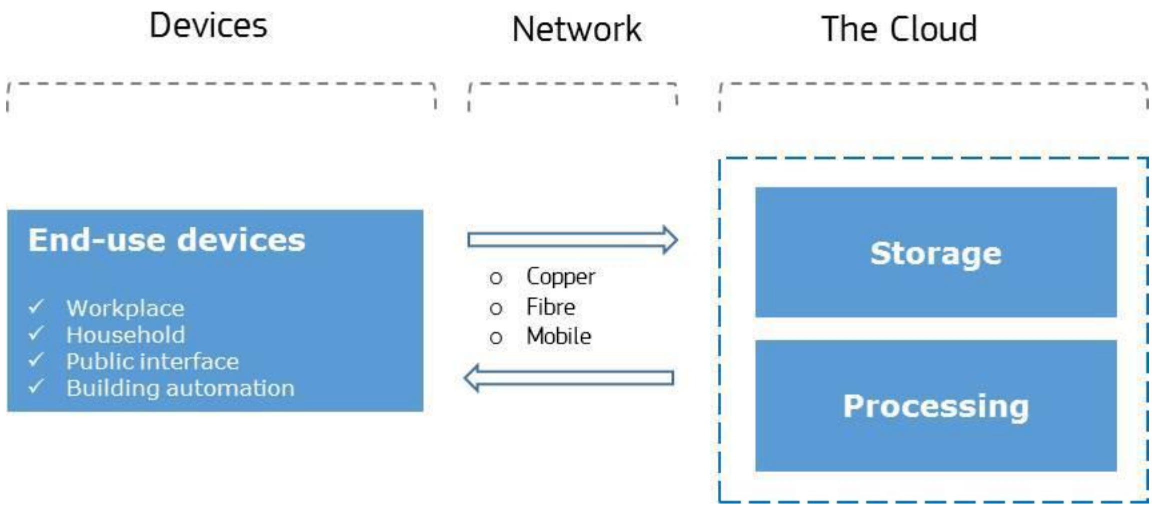

Figure 1: Use of ICT End-user devices and relationships with telecommunication network and cloud

3 Environmental impacts of the ICT sector: a preliminary overview

The number of devices connected to the Internet, including the machines, sensors, and cameras that make up the Internet of Things (IoT), continues to grow. The International Data Corporation (IDC) estimates that in 2025 there will be 41.6 billion connected devices in the world. This means an enormous amount of data produced and stored in data centres, transmitted by the telecommunication network infrastructure but also used and stored at the endpoint ICT devices (such as PCs, smartphones, and IoT devices).

This growth in terms of devices and data processing and transmission could result in increasing pressure and impacts on the environment. Relevant environmental aspects and impacts recognised to be associated to the ICT sector are summarised in Table 1 below.

Table 1 Key Environmental Aspects and Impacts of ICT systems

Key Environmental Aspects and Impacts
• Use of finite resources, including critical raw materials to produce ICT devices • Energy consumption and resulting Greenhouse Gas emissions from production and use of ICT devices • Air, soil and water pollution, bioaccumulation and effects on organisms due to raw material extraction and processing, and hazardous substances used in ICT products. • Generation of potentially hazardous electronic waste upon its final disposal

3.1 Materials

ICT is based on a multitude of hardware devices with specific, complex material compositions. The average material composition of a consumer ICT device at the end of its useful life (reference year 2010) has the following characteristics: most of the mass of such a device consists of the base metals iron (Fe), aluminium (Al), and copper (Cu), polymers (mainly ABS, PC, PC/ABS, PE, PS, and SAN) and glass. Besides the three base metals, consumer ICT devices also contain a large number of scarce metals, including, among others, gold (Au), indium (In), platinum group metals (PGM) such as palladium (Pd) and platinum (Pt), rare earth elements (REE) such as dysprosium and neodymium, silver (Ag), and tantalum (Ta). In the last few decades, an increasing number of elements represented in the periodic table has found its way into both infrastructure (e.g., servers, routers, switches, base stations, and optical fiber cables) and consumer ICT devices. However, the material composition of ICT devices tells only part of the story about the material basis of ICT. Both ''upstream'' processes (mining, refining, and production of the raw materials; production and assembly of the components; and the product itself) and ''downstream'' processes (product use, materials recovery, and final disposal) associated with an ICT device generate a multitude of material flows which are not obvious to its user.

The increased demand for data usage will have a big impact on technologies for data storage, including the additional demand of materials for memories production[2]. Many CRMs are particularly essential for ICT in general, and more in particular for data storage.

Based on Ku (2018), the expected 2025 global datasphere could require up to 80 kilotonnes of neodymium, about 120 times the current yearly EU demand of this material. Using instead emerging technologies such as ferroelectric RAM would require up to 40 kilotonnes of platinum, which is about 600 times the current yearly demand of the EU (European Commission, Joint Research Centre, 2020).

Trade of some minerals used in IT products, such as tantalum and gold, can be used to fuel violence, human rights abuses or other crimes (European Commission, 2017). Unsafe mining methods also lead to severe health problems for workers and environmental degradation in the communities where they live (TCO Development, 2020).

[2] European Commission, (2020). Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020

3.2 Manufacturing

According to Cabernard et al. (2019), between 1995 and 2015, climate change impacts of ICT manufacturing have doubled and the material footprint has quadrupled. In 2015, ICT manufacturing contributed ~ 2% of global climate change impacts, half of which is caused by the production of material resources used for ICT manufacturing.

According to Malmodin and Lundén (2018), the embodied carbon footprint plays a relevant role in the carbon footprint of ICT devices, and it represents the main contribution for small personal ICT devices as notebooks, tablets and smartphones. This is also in line with several peer reviewed studies in the literature.

Environmental impacts from ICT production are to a large extent linked to printed circuit boards (PCB). In particular, production of integrated circuits (IC) mounted on PCBs is consistently reported as environmentally burdensome (André et al., 2019).

3.3 Use Phase

According to VHK and Viegand Maagøe (2020), the ICT products consume almost 260 TWh or ~10% of the EU27 electricity consumption. This is less than electricity consumption for light sources, more than electricity for water heaters and comparable to the annual electricity consumption of Spain or Turkey. In terms of net final energy consumption, i.e. following the accounting principles of the Eurostat energy balance sheets, ICT consumes 2% of the EU27 total. Electricity use for ICT is declining after peaking in the year 2012 at 289 TWh/yr, the ICT electricity use decreased on average by 1.7% annually and is expected to reach 240 TWh/yr by 2022. Despite the exponential increase in data traffic and ICT product performances over the period, the energy efficiency of ICT-related products increased even more.

At global level, demand for data centre and network services are expected to grow strongly in the next years, driven in particular by rapidly growing demand from streaming video and gaming. According to the International Energy Agency (2020), between 2019 and 2022, traffic from internet video is projected to more than double to 2.9 ZB[3], while online gaming is projected to quadruple to 180 EB.6 Together, these streaming services are projected to account for 87% of consumer internet traffic in 2022. Additionally, emerging digital technologies such as machine learning, blockchain, 5G, and virtual reality are also poised to raise demand for data services.

In terms of energy consumption, the strong growth in demand for data centre services has been, until now, almost entirely offset by efficiency improvements for servers, storage devices, network switches and data centre infrastructure, as well as a shift to much greater shares of cloud and hyperscale data centres. However, the efficiency trends of current technologies could slow (or even stall) in upcoming years and the overall energy and emission impacts of 5G are still uncertain (IEA, 2020).

Belkhir, L. and Elmeligi A., (2018) estimate that contribution of ICT to the total carbon footprint has grown from a 1% in 2007 to more than double in 2020, reaching a 3% of the total worldwide GHGe with the contribution of the ICT infrastructure (data centre and telecommunication networks) making up the lion share of the overall industry impact, growing from 61% in 2010 to 79% in 2020. The same researchers estimate that by 2040, carbon emissions from the production and use of electronics, including devices like PCs, laptops, monitors, smartphones and tablets and related ICT infrastructure (data centres and telecommunication networks) could reach 14% of the global GHG emissions.

Consumer's ICT devices (such as smartphones, tablets, notebooks) are also characterised by relatively short lifetimes and after active use they are sometimes stored for up the equivalent of the length of active use, and a large proportion of products that are not actively used are still in good working condition (Zhilyaeva et al. 2021).

The implementation of material efficiency strategies (durability reparability, upgradability, reusability) to extend the length of the product use can reduce the overall impacts associated to the use of ICT.

3.4 End of Life

Recycling rates for ICT devices are globally low. Even in the EU, which leads the world in e-waste recycling, just 35% of e-waste is officially reported as properly collected and recycled[4]. Globally, the average is 20%

[3] This estimation does not take in to consideration the systemic effects of the COVID-19 crisis.
[4] https://ec.europa.eu/eurostat/databrowser/view/t2020_rt130/default/line?lang=en

and the remaining 80% is undocumented, with much ending up buried under the ground for centuries as landfill (PACE 2019).

4 Current policies and initiatives

Up to the 2019 the policy measures adopted by the Commission in the field of ICT focused mainly on the Energy Efficiency of end user ICT devices.

In 2019, a number of measures under the Ecodesign Directive were adopted which introduced also requirements related to material efficiency. Amongst other products, ICT sector products were also included, such as servers and data storage products, and electronic displays (including televisions). The requirements introduced included:

- for servers:
  - ensuring that joining, fastening or sealing techniques do not prevent the disassembly for repair or reuse purposes for a number of components;
  - the availability of a functionality for secure data deletion;
  - the availability of firmware (and the latest available security update) for a period of eight years free of charge or at a fair, transparent and non-discriminatory cost.
  - instructions on the disassembly operations

- for electronic displays:
  - ensuring that joining, fastening or sealing techniques do not prevent the disassembly for repair or reuse purposes for a number of components;
  - the availability of dismantling information needed to access product components referred.
  - The marking of plastic components heavier than 50g and flame retardants
  - A cadmium-inside or cadmium-free logo
  - A restriction of use of halogenated flame retardants in the enclosure and stand of electronic displays
  - The availability of spare parts to professional repairers for a number of years
  - Ensuring that spare parts can be replaced with the use of commonly available tools and without permanent damage to the appliance;
  - Access to repair and maintenance information
  - the availability of firmware (and the latest available security update) for a period of eight years free of charge or at a fair, transparent and non-discriminatory cost.

More advanced material efficiency criteria have been introduced at voluntary level (EU Ecolabel / Green Public Criteria) and for several categories of ICT devices: EU GPP for Computers and Displays, EU GPP Criteria for Data Centres; EU GPP Criteria for Imaging Equipment EU Ecolabel Criteria for Electronic Displays, among others.

Furthermore, in its 2020 Circular Economy Action Plan[5], the European Commission further recognised the sector of Electronics and ICT as a contributor to increasing waste streams in the EU. A number of measures are thus proposed, such as ecodesign measures related to mobile phones, tablets and laptops under the Ecodesign Directive, as part of the 'Circular Electronics Initiative'.

In particular the following actions are planned in the time period 2020-2022:

- New and or revised ecodesign measures for electronics and ICT computers including mobile phones, tablets and computers in order to ensure that devices are designed for energy efficiency and durability, reparability, upgradability, maintenance, reuse and recycling.
- focus on electronics and ICT as a priority sector for implementing the 'right to repair', including a right to update obsolete software;
- regulatory measures on chargers for mobile phones and similar devices, including the introduction of a common charger, improving the durability of charging cables, and incentives to decouple the purchase of chargers from the purchase of new devices;

[5] COM(2020)98 A new Circular Economy Action Plan For a cleaner and more competitive Europe

- improving the collection and treatment of waste electrical and electronic equipment including by exploring options for an EU-wide take back scheme to return or sell back old mobile phones, tablets and chargers;
- review of EU rules on restrictions of hazardous substances in electrical and electronic equipment and provide guidance to improve coherence with relevant legislation, including REACH and Ecodesign.

The CEAP plan also foresees initiatives enhancing the sustainability of the batteries. A new legislative proposal will build on the evaluation of the Batteries Directive and the work of the Batteries Alliance. Possible aspects that would be addressed are rules on recycled content, sustainability and transparency requirements, the carbon footprint of battery manufacturing, the ethical sourcing of raw materials and security of supply, and facilitating reuse, repurposing and recycling.

5 Scope of the study (1): order of effects

This project's aim is to determine the best policy approaches for improving the environmental performance of ICT. Based on the scientific evidence JRC will produce recommendations on the inclusion of Ecodesign Criteria, but also on complementary policy tools to improve the sustainability of ICT products and systems.

The overall scope of the project includes the direct life cycle impacts of ICT devices (production – use – disposal) but also aspires to go beyond that. ICT systems can themselves have an impact on the environment, so also have the potential to themselves become more sustainable over their whole life cycle, mainly by an reduction of the energy and material flows they invoke (Sustainability in ICT). At the same time, ICT has the potential to trigger wider effects, either by creating, enabling, and encouraging sustainable patterns of production and consumption (Sustainability by ICT), or by stimulating ever increasing consumption.

Hilty et al., 2015 developed a 'framework for ICT Impacts on Sustainability' (Figure 2), consisting of three orders of effects and a categorisation based on whether the environmental impact is positive (part of the solution) or negative (part of the problem).

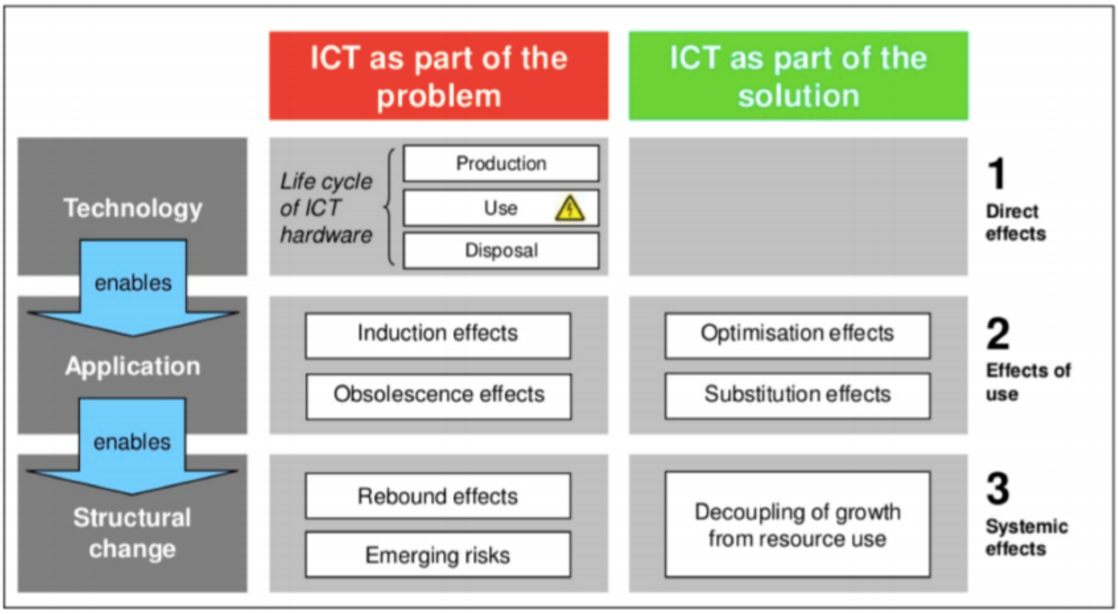

Figure 2: A matrix of ICT environmental effects (Hilty et al., 2015)

First Order Effects

First Order (Level 1) effects refer to the direct effects of the production, use and disposal of ICT, and are effects that can be assessed with a Life-Cycle Assessment (LCA) approach at device level (attributional LCA) (Pohl et al., 2018). In particular, this includes the demand for materials and energy throughout the whole life cycle of ICT products. These effects are placed entirely on the negative side as they represent the environmental cost of the hardware providing ICT services. These effects are typically addressed by European Product Policy tools such as the Ecodesign Directive, the Energy Labelling, the EU Ecolabel and Green Public Procurement.

Second Order Effects

Second Order (Level 2) refers to the enabling effects of ICT systems, or the effects of applying ICT. These are indirect environmental effects of ICT due to its power to change processes, resulting in a modification (decrease or increase) of their environmental impacts. From a sustainability point of view, these effects may be positive or negative:

Negative effects:

— Induction effect: ICT stimulates the consumption of another resource. For example, the increased connectivity and performance of ICT devices can affect the use of telecommunication infrastructure and the related energy demand for data storage, processing and transmission.

— Obsolescence effect: ICT can shorten the useful life of another resource due to incompatibility, a device that is no longer supported by software updates is rendered obsolete. ICT is also characterised by rapid technological development, for instance in terms of computational power and memory capacity. A downside of rapid technological development is the risk of premature obsolescence and underutilised lifetimes. Short technology cycles, new functionalities and features (e.g. for smartphones) often trigger product replacement (functional and psychological obsolescence) more than technical failures do (Proske et al., 2016) (Zhilyaeva et al. 2021).

Positive effects:

— Substitution effect: The use of ICT replaces the use of another resource (e.g. an e-book reader can replace printed books, which is positive if it avoids the printing of a sufficiently large number of books).

— Optimization effect: The use of ICT reduces the use of another resource (e.g. less energy is used for heating in a smart home that recognises where occupants are located, which windows are open, what weather is forecast, etc.).

Third Order Effects

Hilty et al., 2015 also describes Third Order (Level 3) effects. The Third Order refers to the systemic effects, i.e. the long-term reaction of the dynamic socio-economic system to the availability of ICT services, including behavioural change (lifestyles) and economic structural change. On the negative side, rebound effects prevent the reduction of total material resource use despite decoupling (see by converting efficiency improvements into additional consumption). On the positive side, ICT has the potential to support sustainable patterns of production and consumption.

The impacts of such effects, especially high order ones, are not easily captured and quantified. The deployment of ICT systems is complex and variable, while there are still data gaps on how humans interact with systems. As a result, findings so far are associated with uncertainty, meaning that although there is an understanding that ICT has large energy saving potential, the realization of that potential is by no means assured. For example, a set of case studies conducted in the EU find ICT-related rebound effects from e-commerce and telework ranging from 14% to 73% (Jørgensen et al 2006). Third order sustainability effects are not included in the scope of this study.

6 Scope of this study (2): product groups

In their "ICT Impact Study", VHK and Viegand Maagøe (2020) consider the product (sub)groups listed in Table 2 below. As this wealth of products are interconnected within an ICT system, the present study aims to analyse the environmental aspects of ICT from an end-use perspective. The rationale for the selection of this scope is threefold:

- end-user devices are responsible for relevant first order effects (life cycle impacts) as described above;
- to investigate the ever-increasing environmental impacts of relevant secondary effects which are associated to the end use of ICT devices (e.g. the increasing data demand driven by video streaming or on line gaming);
- to focus on end-use allows for exploring legislative options that are more likely to be compatible with an EU product policy framework.

The present study will focus on the end-use devices with highest potential for improvement among the products listed in Table 2. The focus on end-use devices does not imply that products related to other parts of an ICT system as in Figure 1 (e.g. data storage or transmission devices) will be ignored. Those products will be considered as far as the environmental impact of their use phase is associated with the usage patterns of end-devices.

In that sense, this study is extending beyond the limitations of typical ecodesign preparatory studies. Many ICT-related products are covered by the implementation of European sustainable product policies such as: Ecolabel, Green Public Procurement, ErP (Ecodesign of Energy related Products) and Energy Label and by voluntary agreements (VA). Product policy processes are ongoing for relevant products are computers and smartphones. and more ICT products are expected be part of the ecodesign & energy labelling working plan 2020-2024.

Table 2: List of product Groups in the scope

Product Group	**Sub categories**	**Existing EU legislation**
Data Centre Devices	Servers	ErP (EU) 2019/424 EU GPP Criteria SWD(2020)55 final
	Storage	ErP (EU) 2019/424 EU GPP Criteria SWD(2020)55 final
	Networking (switches/routers)	
	UPS	
	Cooling Equipment	
Telecommunication Network	Broadband communication equipment	
	Network in Offices (1GB/10+ GB LAN, WLAN)	
	Mobile networks (mobile radio, aggregate/core, satellite TV, TETRA, 2G, 3G, 4G, 5G	
	Cable (fixed, landline) networks (i.e. PSTN/KSDN, TV-cable, ADSL, VDSL,	

		FTTLA, FTTH/B, FTTH)	
End user devices	Electronic displays	Televisions	ErP (EU) 2019/2021; Energy Labelling (EU) 2019/2013
		Monitors	
	Audio/video devices	video players/recorders	
		video projectors / beamers	
		video game consoles	VA COM/2015/0178 (under revision)
		interactive whiteboards	
		videoconference systems	
		MP3 players	
		stand-alone home audio	
		network connected home audio	
		complex set-top boxes	VA COM/2012/0684 (retired)
		digital TV services	
	Personal ICT Equipment	Desktop PCs,	ErP (EU) 617/2013 EU GPP Criteria SWD(2016) 346 final (under revision)
		Workstations	
		Notebooks/Laptops	
		Tablets/Slates	
		Home/Office fixed phones	
		Smartphones	ErP (under development)
	Imaging Equipment	Monochrome laser MFD (Multi-Functional Printer)	VA COM/2013/023 (under revision) GPP (SWD(2020) 148 final)
		Colour laser MFD	
		Monochrome laser printer	
		Colour laser printer	
		Colour inkjet MFD	
		Colour inkjet printer	
		Professional printer and MFD	

		Scanner	
		Copier	
		Facsimile (fax) machine	
		3D Printers	
	Home / Office Network Equipment	Home gateway / IoT access devices	
		Home routers/gateways, integrated access devices	
		Base stations	
		Home network equipment	
		Office network equipment (servers, routers, switches)	
		Home NAS	
	ICT in public Space	ATMs	
		Cash Registers and POS Terminals	
		Ticket Machines	
		Public WLAN hotspots	
		Toll-related ICT	
		Security cameras	
	Building Automation and Control		ErP (under development)
	Industrial Sensors		
	Uninterruptible Power Supply (UPS)		
	Audio Equipment	Loudspeakers	
		Radios	
		Players/recorders	
		Amplifiers	
		Receivers	
		Tuners	
		Microsets	

		Wireless speakers	
		Smart speakers	
		Soundbars	
		Network audio players	

In summary, the scope of this study can be presented in Table 3 below.

Table 3: Summary of study scope

		ORDER OF EFFECTS		
		FIRST ORDER	**SECOND ORDER**	**THIRD ORDER**
PRODUCT/ DEVICE TYPES	CLOUD	production	Induction	
		use	Obsolescence	Rebound effects
		end of life	Substitution Optimization	Emerging Risks
	NETWORK	production	Induction	
		use	Obsolescence	Rebound effects
		end of life	Substitution Optimization	Emerging Risks
	END-USE	production	Induction	
		use	Obsolescence	Rebound effects
		end of life	Substitution Optimization	Emerging Risks

Within study scope
If linked with end-use
Out of study scope

7 Research questions

What are the main technological and market trends of ICT? And what are their impacts (both positive and negative) from an environmental point of view?

What are the product lifecycle aspects (first order effects) that will need more attention in the next years? (e.g. use of materials, manufacturing processes, energy consumption in the use phase, lifetime extension, end-of life management). How can these first order effects be addressed by product policy (i.e. Ecodesign Directive)?

The importance of seeing the effects outside the device boundary: How relevant are higher order effects from an environmental point of view? (e.g. induction and obsolescence from the negative side, substitution and optimization from the positive side)?

More specifically, on induction: Does the use of ICT devices / services contributes to relevant impacts outside the end-user device life cycle (e.g. telecommunication network and data centres)? If these effects are relevant, at what extent can be addressed by product policy (i.e. Ecodesign Directive)? What could be the role of consumers and consumer policy?

Obsolescence: are the obsolescence effects of a fast evolving ICT sector relevant from an environmental point of view? Is product lifetime limited by technical devices issues or by more systemic functional obsolescence issues as incompatibility, software updates, or storage/memory needs? Or by consumer preference for new device? If these obsolescence effects are relevant, at what extent can be addressed by product policy (i.e Ecodesign Directive)? What could be the role of consumers and consumer policy? And what can be done at waste policy level?

Substitution and Optimisation effects: how are these effects considered in the global environmental assessment of ICT? Are the benefits from these effects relevant? If yes, how the EU can support these positive effects? at what extent this can be addressed by product policy (i.e. Ecodesign Directive)? What could be the role of consumers and consumer policy? And what can be done by other policy tools.

Also in terms of first order effects, does efficiency of devices compensate for the increased data demand (access, network) deriving for e.g. from higher resolution video streaming? Which of these effects can be addressed by product policy tools? Which of these aspects need different policy approaches? (e.g. physical and technical aspects vs. business drivers, consumer behaviour)

References

André H., Söderman M., Nordelöf A. (2019). Resource and environmental impacts of using second-hand laptop computers: A case study of commercial reuse Waste Management 88 (2019) 268–279

Belkhir, L., Elmeligi A., (2018) Assessing ICT global emissions footprint: Trends to 2040, Journal of Cleaner Production 177 (2018) 448-463, DOI: 10.1016/j.jclepro.2017.12.239

March 2018, www.sciencedirect.com/science/article/pii/S095965261733233X?via%3Dihub

Cabernard L, Pfister S., Hellweg S. (2019) A new method for analysing sustainability performance of global supply chains and its application to material resources. Sci Total Environ 684:164–177

European Commission, Joint Research Centre (2020). Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020" ISBN 978-92-76-15337-5 doi: 10.2873/865242

https://doi.org/10.3390/technologies6030085

Hilty, L.M.; Aebischer, B. ICT for sustainability: An emerging research field. In ICT Innovations for Sustainability; Springer: Berlin, Germany, 2015; pp. 3–36.

IEA (2020) Data Centres and Data Transmission Networks - Tracking report — June 2020. https://www.iea.org/reports/data-centres-and-data-transmission-networks

ISO (2008). ISO 9241-20:2008, Ergonomics of human-system interaction — Part 20: Accessibility guidelines for information/communication technology (ICT) equipment and services

Ku, A.Y. (2018), 'Anticipating Critical Materials Implications from the Internet of Things (IOT): Potential Stress on Future Supply Chains from Emerging Data Storage Technologies', Sustainable Materials and Technologies, Vol. 15, No. October 2017, 2018, pp. 27–32

Malmodin J. and Lundén D. (2018). The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015. Sustainability (2018)

OECD (2011), OECD Guide to Measuring the Information Society 2011, OECD Publishing. http://dx.doi.org/10.1787/10.1787/9789264113541-en

PACE (Platform for Accelerating the Circular Economy) and World Economic Forum (2019). New Circular Vision for Electronics - Time for a Global Reboot.

Pohl J., Hilty L.M., Finkbeiner M., (2018) How LCA contributes to the environmental assessment of higher order effects of ICT application: A review of different approaches. Journal of Cleaner Production 219 (2019) 698-712

Proske, M., Winzer, J., Marwede, M., Nissen, N.F., Lang, K.D., (2016). Obsolescence of electronics – the example of smartphones, Electronics Goes Green 2016. Berlin, Germany.

TCO Development (2020). (https://tcocertified.com/conflict-minerals/)

VHK and Viegand Maagøe (2020). ICT Impact study FINAL REPORT

Zhilyaeva D., Cimpana C,∗, Caoa Z., Liua G., Askegaardb S., Wenzel H. (2021). The living, the dead, and the obsolete: A characterization of lifetime and stock of ICT products in Denmark Resources, Conservation & Recycling 164 (2021) 105-117

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