European Commission

JRC ICT TASK FORCE STUDY

1st Stakeholder Meeting

23/11/2021

Agenda

Welcome and intro to the meeting (DG ENER)

Presentation of progress in project Tasks (DG JRC)

- *Progress in Task 2 – Presentation*
- *Progress in Task 2 - Q&A*
- *Progress in Task 3 – Presentation*

Short break

- *Progress in Task 3 – Q&A*

Next Steps and AOB (DG JRC and DG ENER)

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Study Overview

The aim of this study is:

- Identification of material and energy efficiency improvement potentials
- Analysis of consumer behaviour implications
- Analysis of Life Cycle Costing implications
- Policy recommendations on the inclusion of Ecodesign Criteria and
- Suitability of complementary policy tools to improve the sustainability of ICT products and systems.

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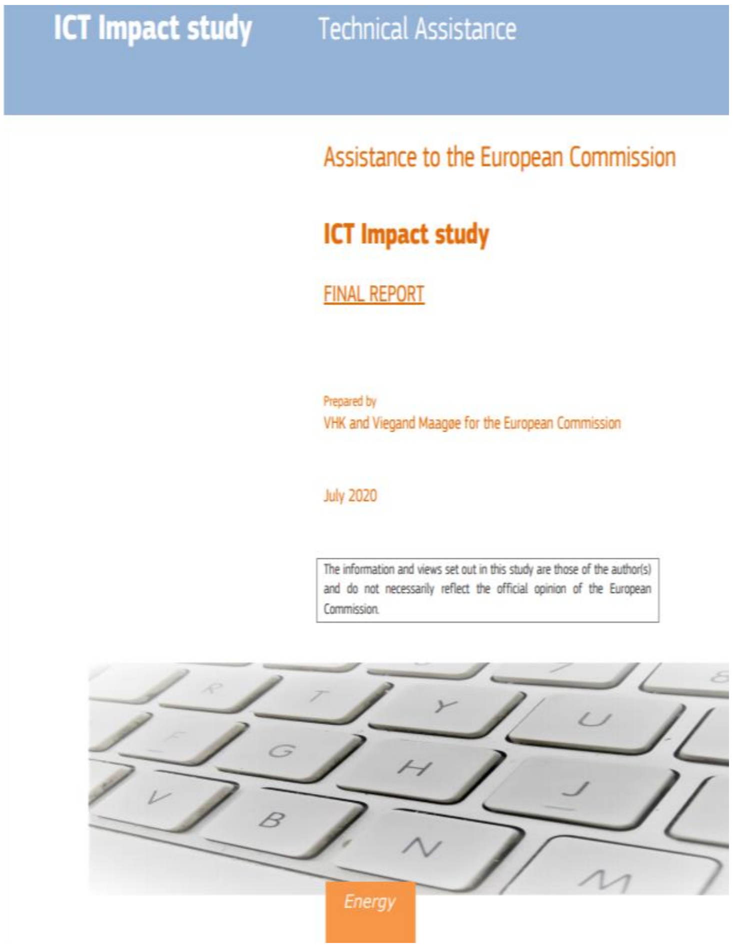
Starting point: VHK/Viegand Maagøe ICT Impact Study


ICT Impact study Technical Assistance

Assistance to the European Commission

ICT Impact study

FINAL REPORT

Prepared by
VHK and Viegand Maagøe for the European Commission

July 2020

The information and views set out in this study are those of the author(s) and do not necessarily reflect the official opinion of the European Commission.

Energy

EU27 market and energy consumption data for 8 main ICT product categories

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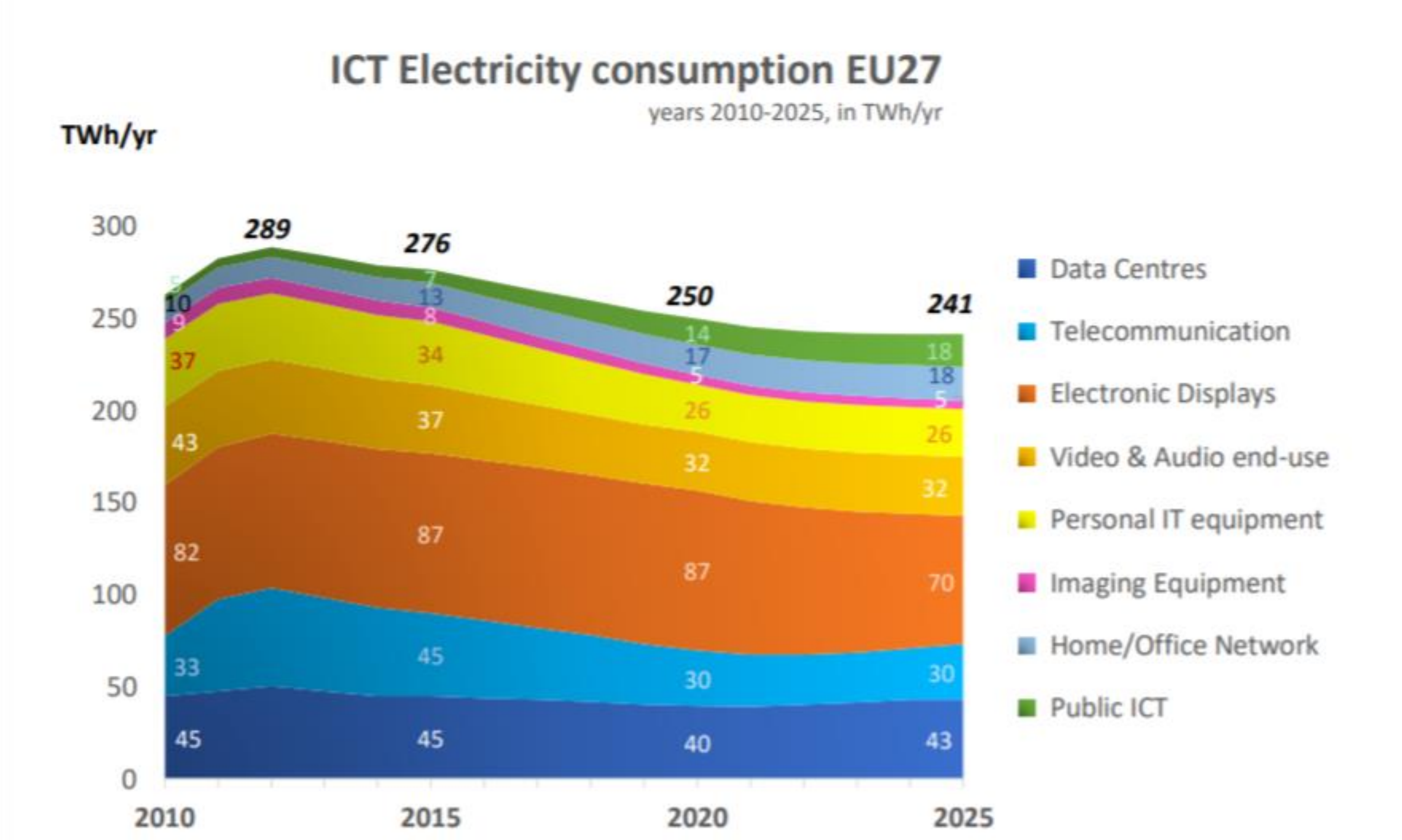
Trends and forecast for the 8 ICT categories in the scope



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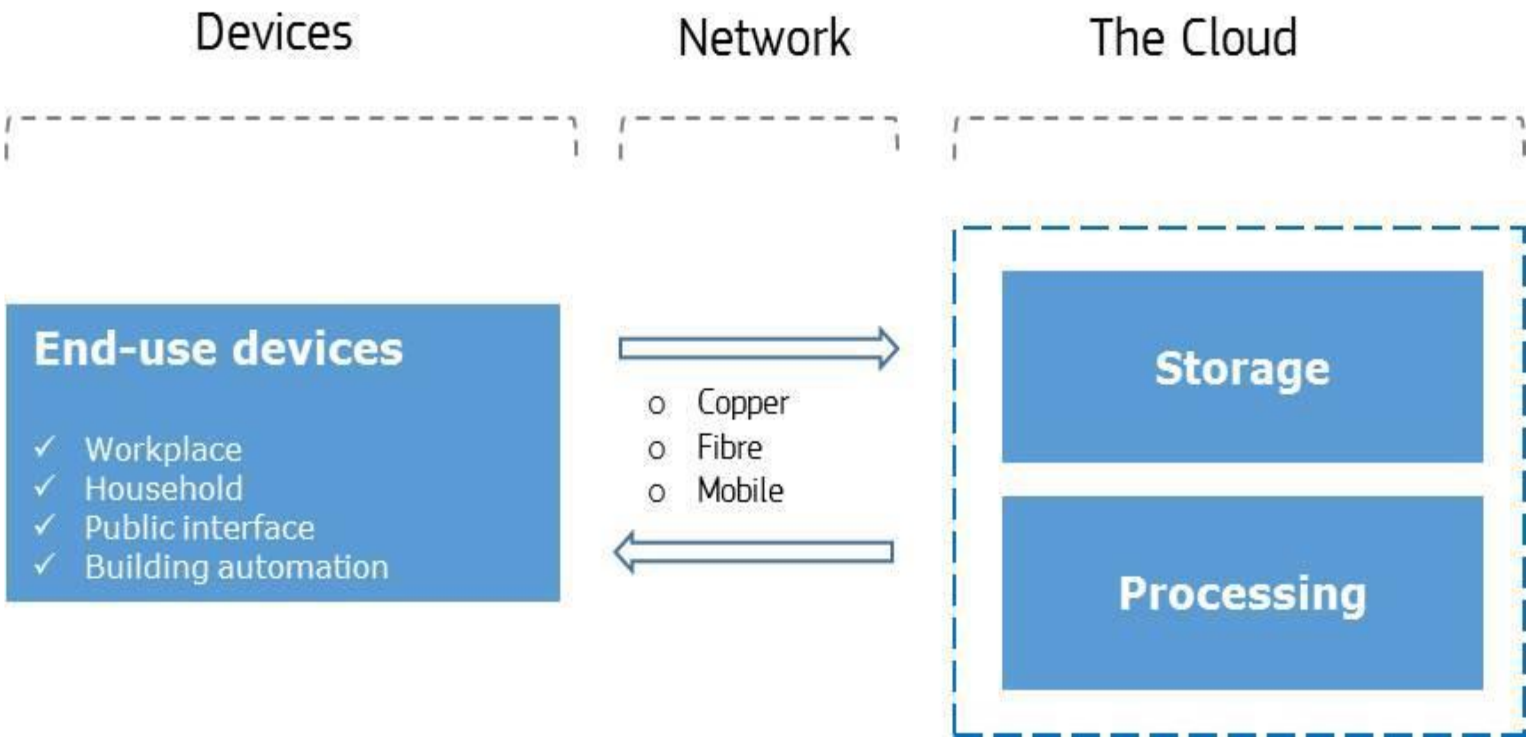
Progress in project Tasks

Task 2: Scope, Definitions and Product Groups covered by this study

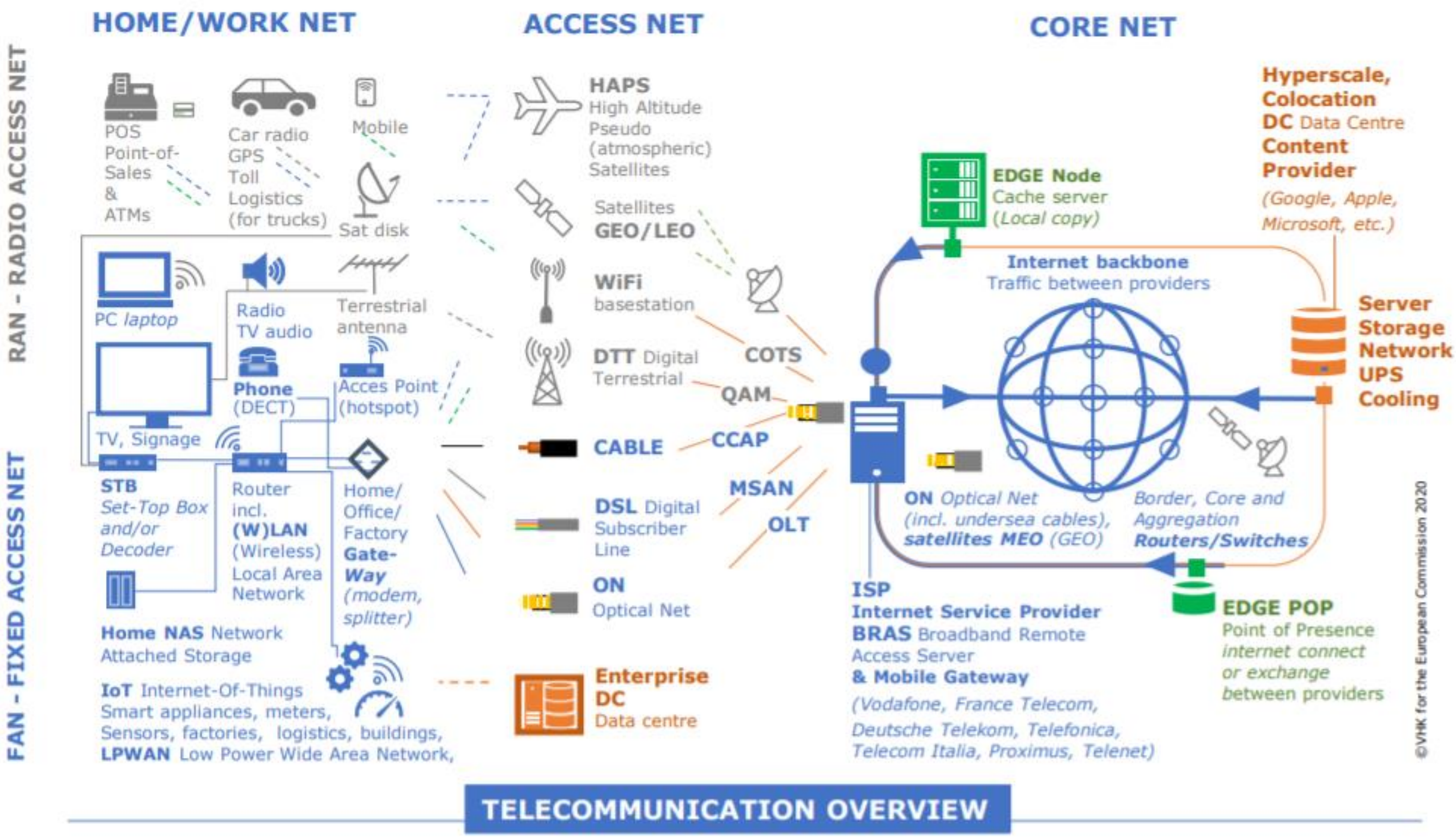
Felice Alfieri, Christoforos Spiliotopoulos
JRC.B.5 Circular Economy and Industrial Leadership

Definition of ICT



The main characteristic that ICT product groups share is that they (increasingly) allow communication between devices

Illustrative overview of the ICT Network



ICT Impacts on Sustainability

Device / Tech – First Order Effects

ICT Application – Second Order Effects

Structural changes – Third Order Effects

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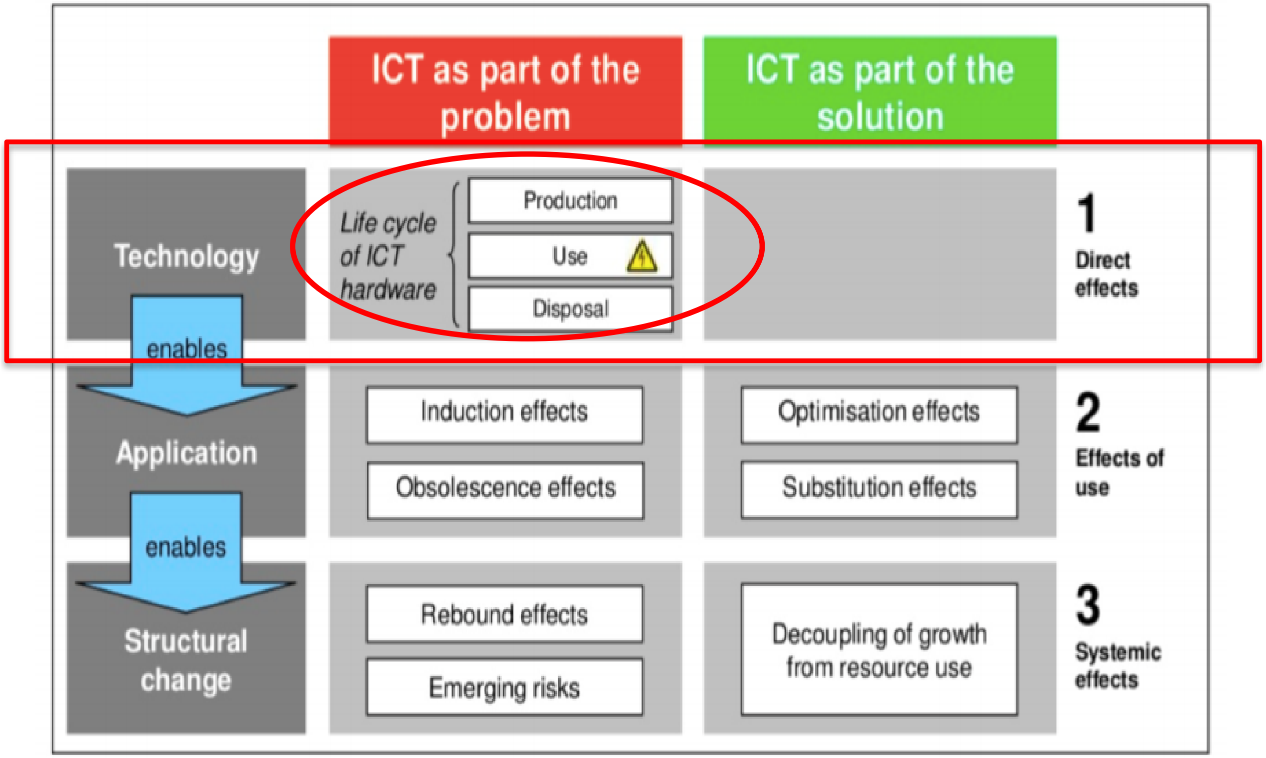
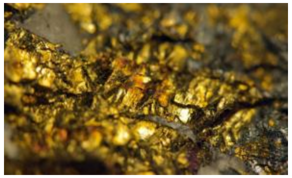
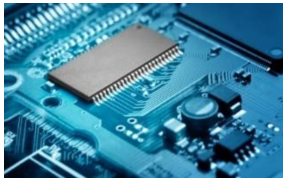
First order effects (Direct effects)

Direct effects



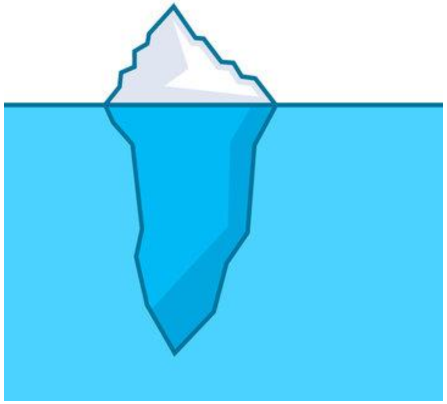




The **direct effects** are related to the life cycle impacts of the ICT hardware (from production to end of life)

Direct Effects

Key Environmental Aspects and Impacts
Use of finite resources, including Critical Raw Materials (CRM).
Energy consumption and GHG emissions from production and use.
Air, soil and water pollution, bioaccumulation and effects on organisms due to raw material extraction and processing, and hazardous substances.
Generation of potentially hazardous electronic waste upon disposal



Systemic aspects?:
(induction, obsolescence, substitution, optimisation, rebound effects, societal structural changes)

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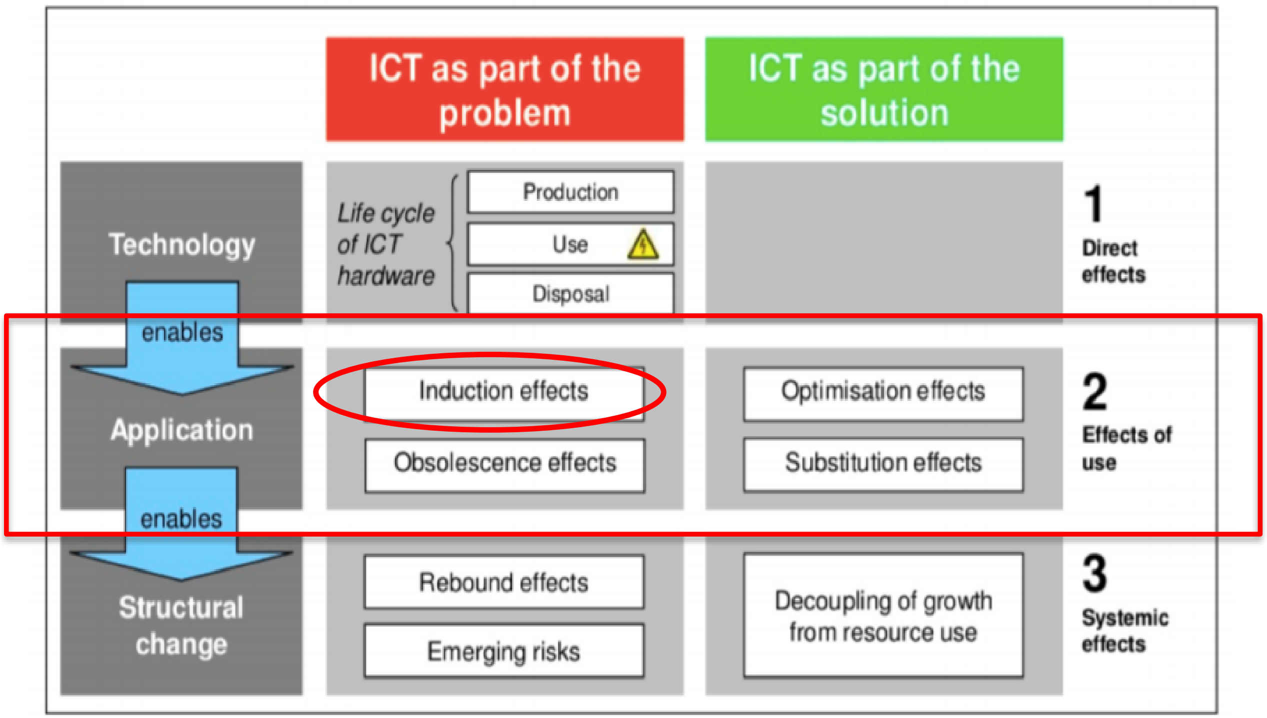
Second order effects
(Enabling Effects)

Second order effects: induction



Induction effect: ICT can stimulate consumption of other resources outside the device boundary (e.g. smart TV can stimulate additional consumption by higher resolution streaming contents)

Smart TV

Streaming Contents

Energy / materials for data storage and transmission

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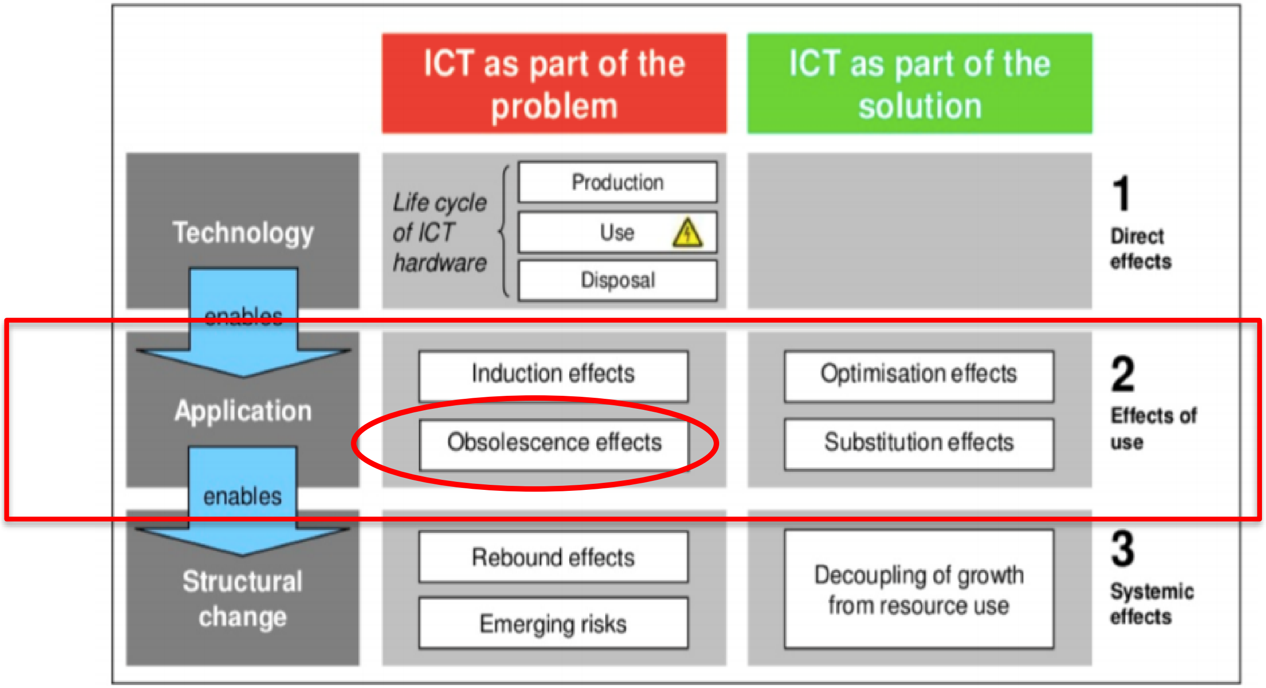
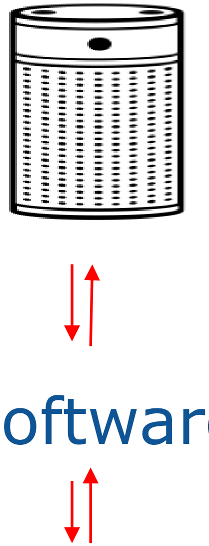
Second order effects: obsolescence





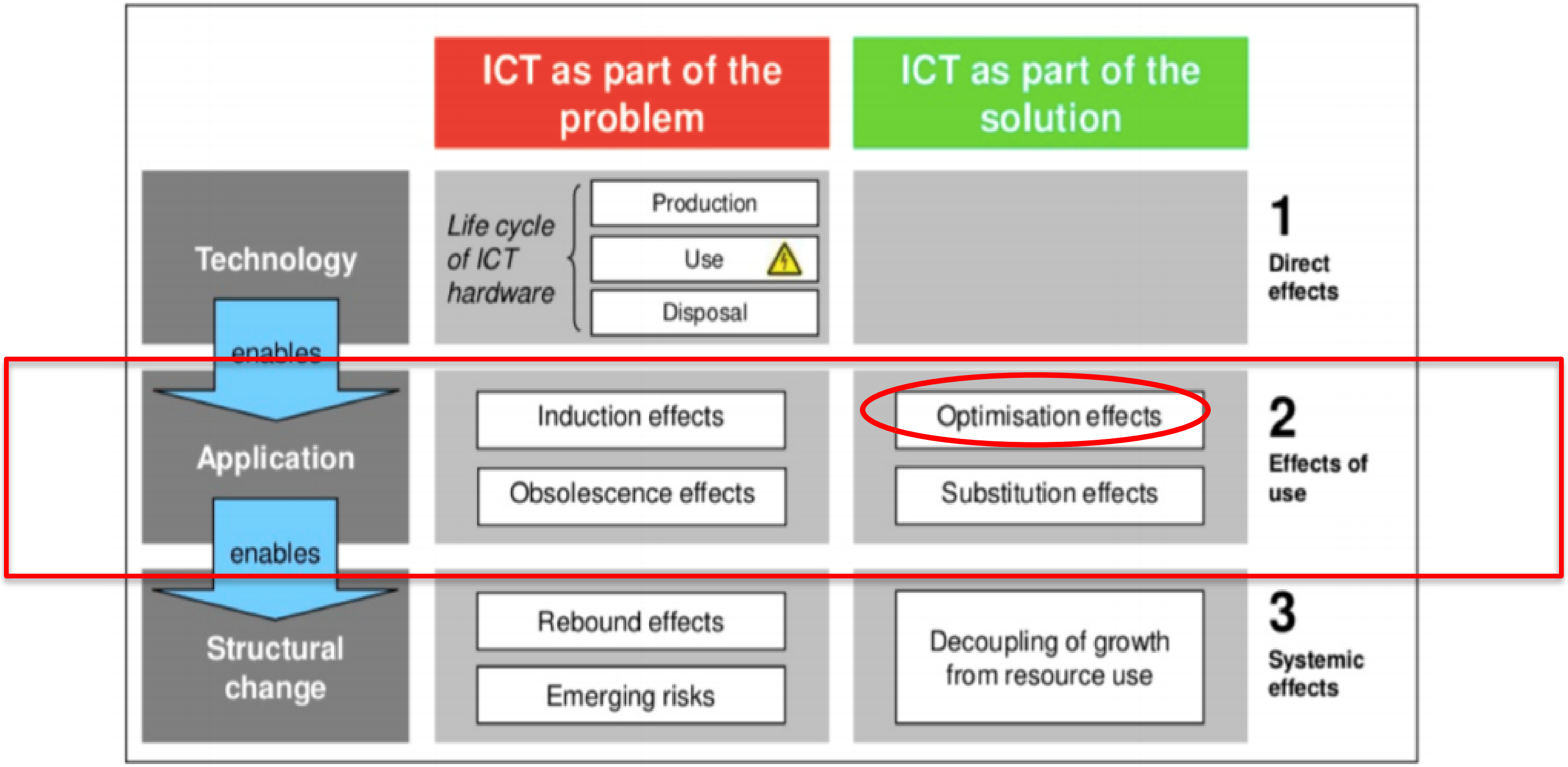
Software

Access to Services

ICT can stimulate functional obsolescence:

- **Incompatibility issues:** a device that is no longer supported by software updates is rendered obsolete
- **New functionalities and features** triggering product replacement

Second order effects: optimisation



Optimization effect: Use of ICT reduces use of resources (e.g. less energy consumption in a smart homes that recognize use profile of occupants and environmental conditions).

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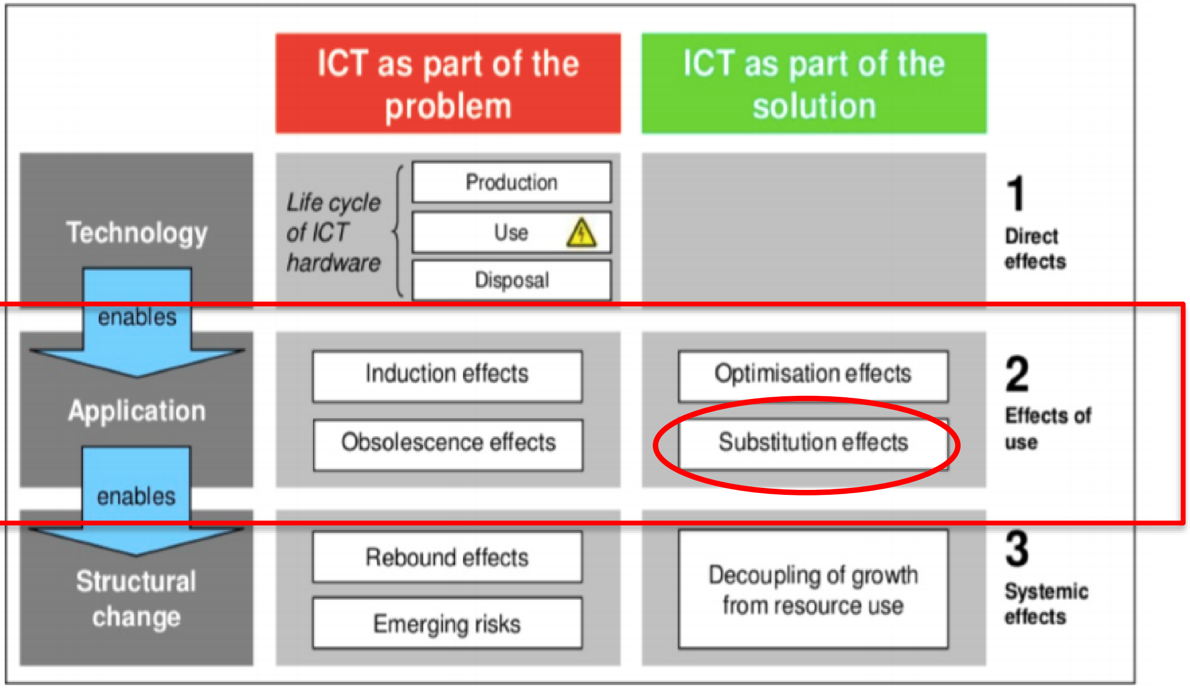
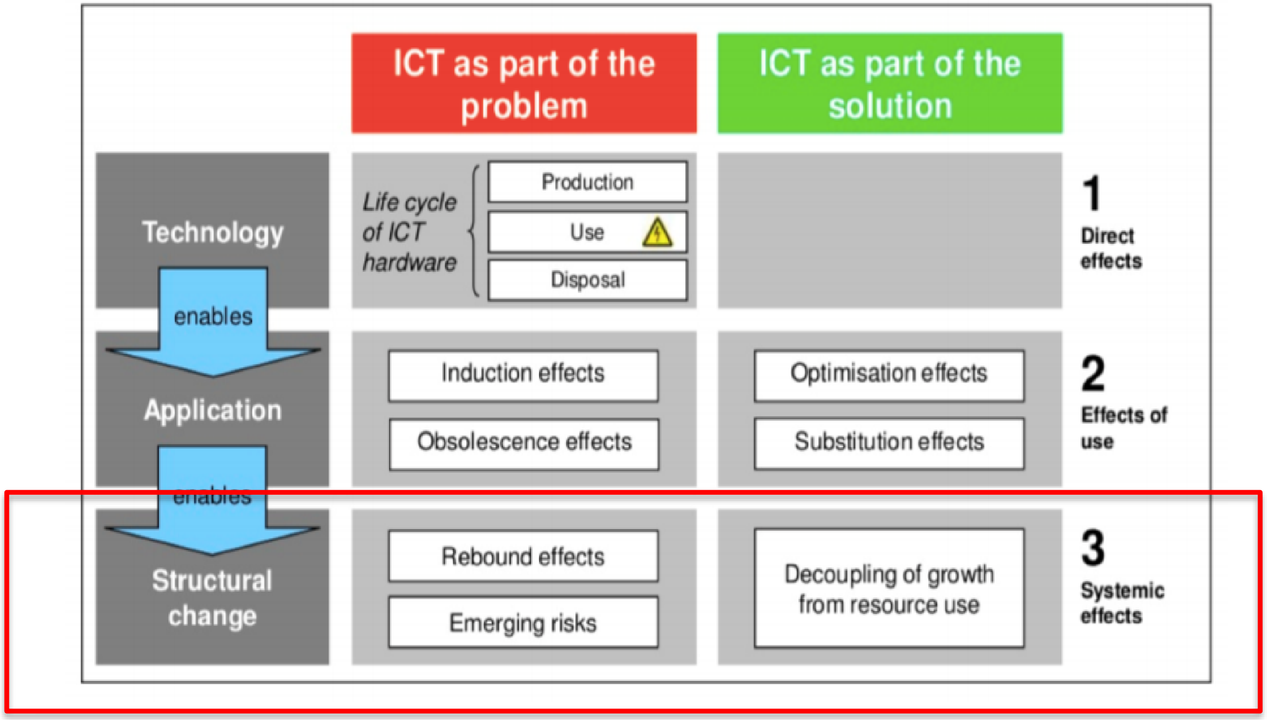
Second order effects: substitution



Substitution effects occur "when an **ICT** service replaces the use of a physical product (e.g. substitution of printed book by e-book; or conference by web-conference).

Third Order Effects
(Structural Changes)

Third order effects



Third order effects *include all the long-term reaction of the dynamic socio-economic system to the availability of ICT services, including behavioural change (lifestyles) and economic structural change.*

The scope proposed under this study

		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

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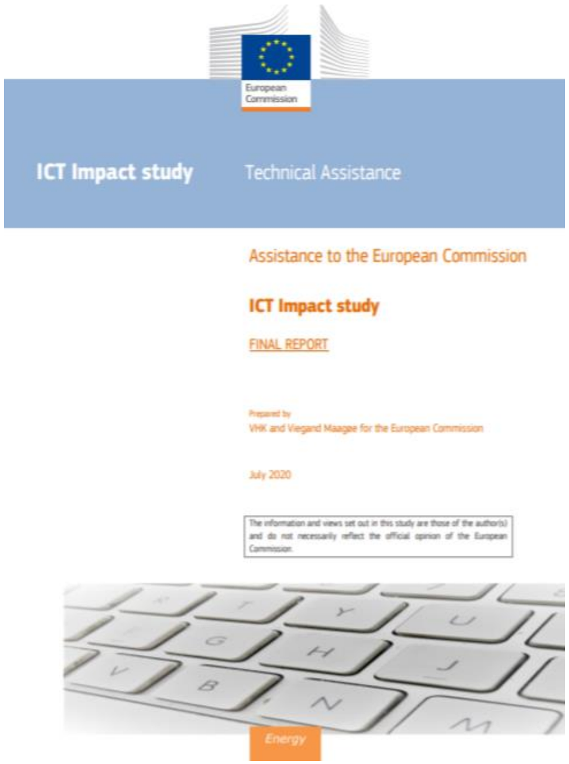
Task 2
Questions / Comments?

ICT TASK FORCE STUDY

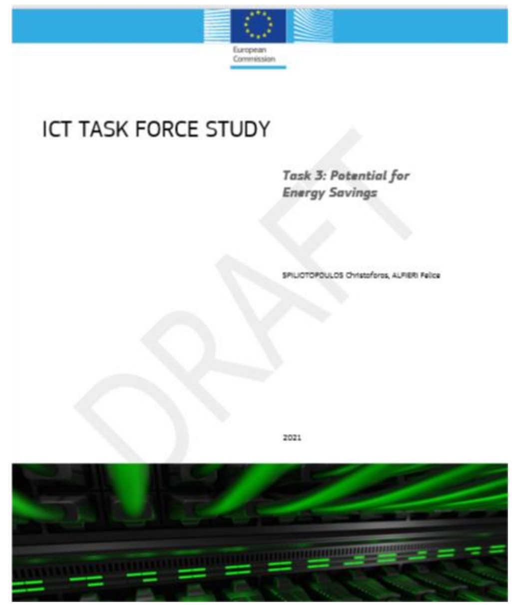
Task 3: *Potential for Energy Savings*

Felice Alfieri, Christoforos Spiliotopoulos
JRC.B.5 Circular Economy and Industrial Leadership

Scope of the analysis (Task 3)



Energy in the use phase of the device



- Embodied energy and carbon
- Induction effects on network and data centres
- Optimisation and substitution opportunities

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First order effects (Direct effects)

Energy Consumptions and GHG Emissions

Embodied energy (and carbon) vs. energy consumption

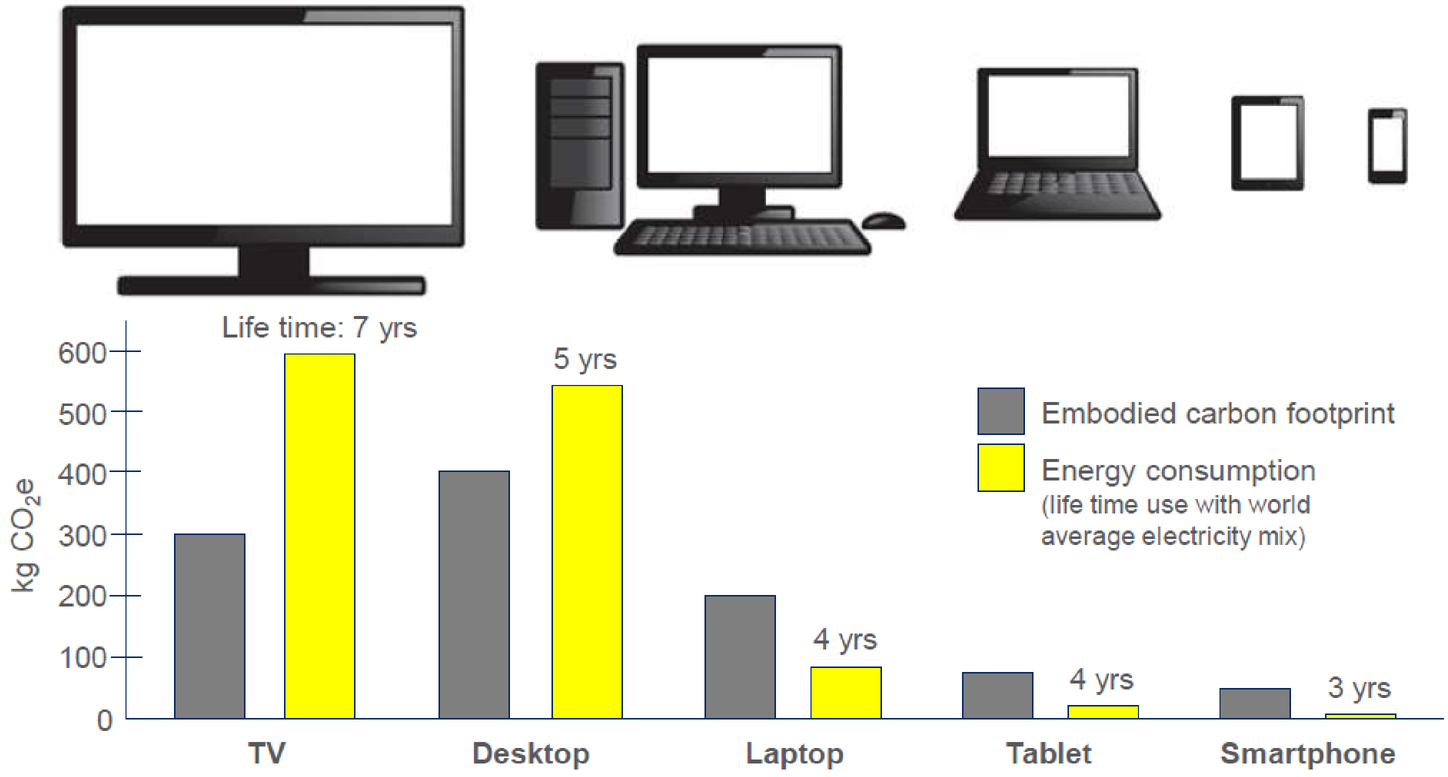

Figure 1: Estimated embodied carbon footprint and use (active lifetime) carbon footprint for common end user ICT devices. Source: Malmodin and Lunden (2018)

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Embodied carbon by component

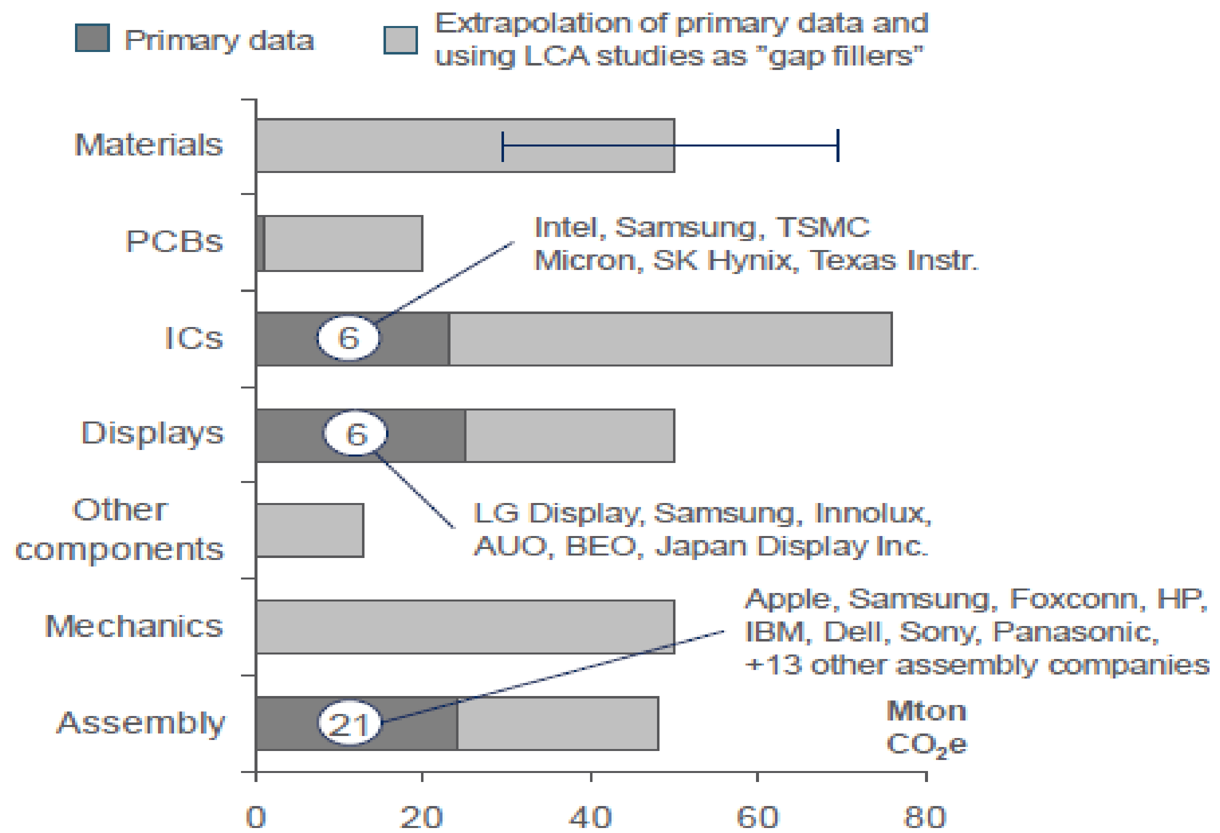

Figure 2: Total Carbon Footprint of the material acquisition and production stage for ICT user devices. The range indicated in materials shows the impact of recycling. Source: Malmodin and Lunden (2018).

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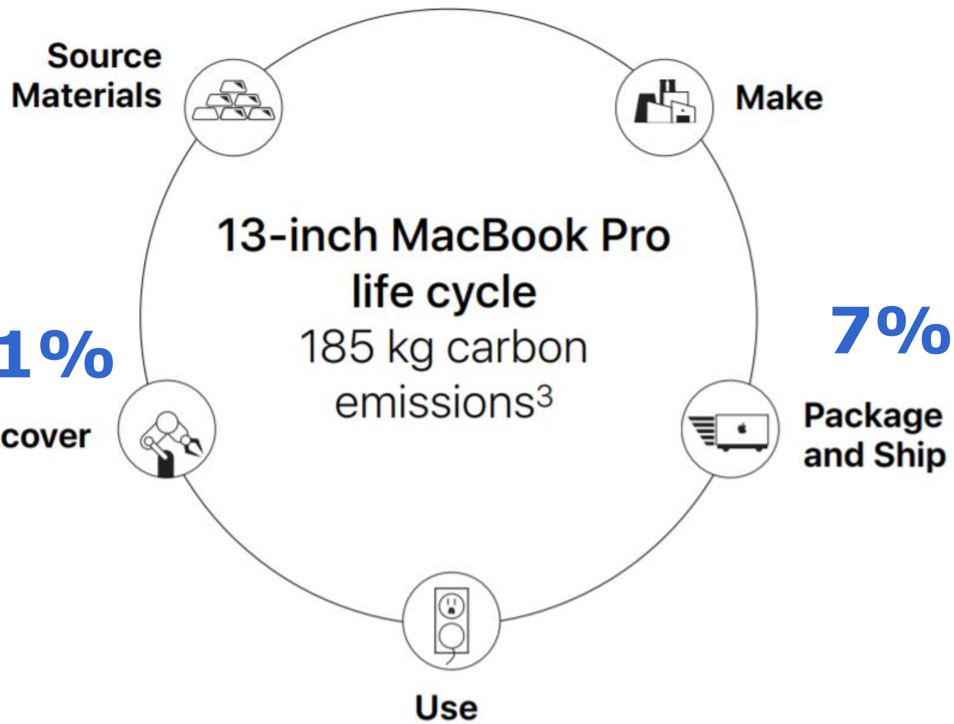
Embodied carbon: notebooks

73%



<1%

7%

19%

https://www.apple.com/environment/pdf/products/notebooks/13-inch_MacBookPro_PER_Nov2020.pdf

256 GB version = 185 kg CO_2
512 GB version = 207 kg CO_2
4 Thunderbolt3 ports + 1TB = 298 kg CO_2

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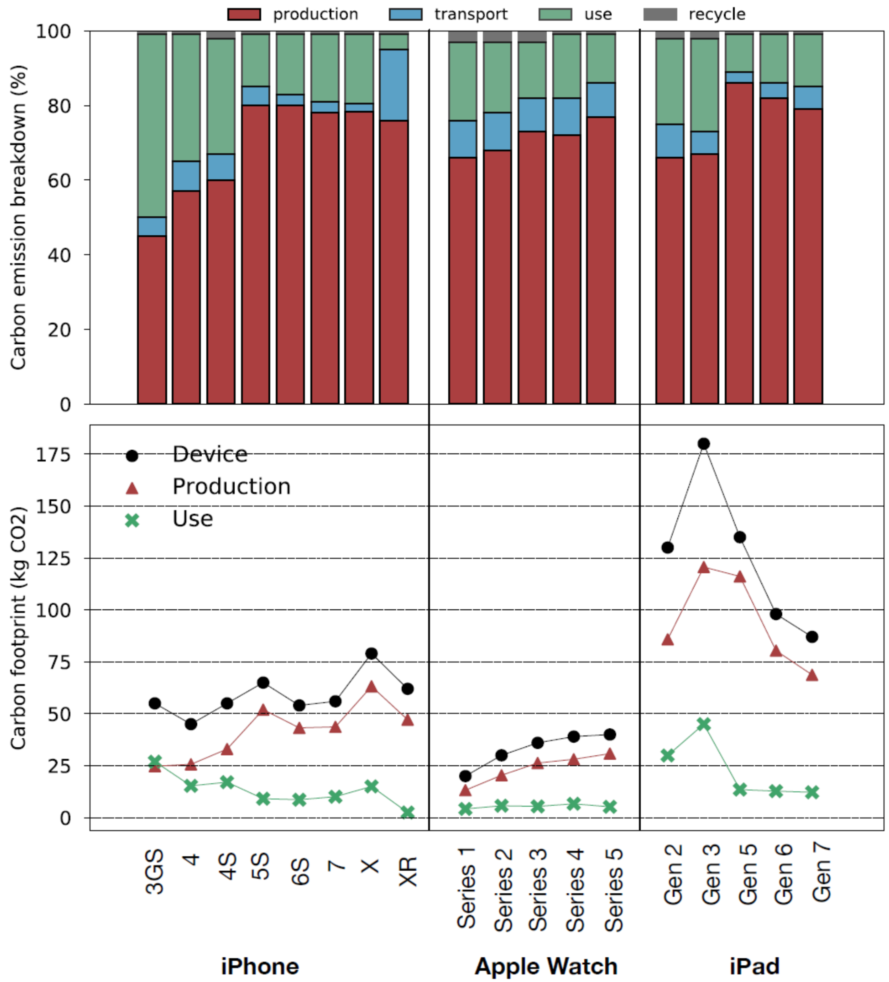
Embodied energy vs Energy Use



The hardware-manufacturing footprint increases with increasing hardware capability (e.g., flops, memory bandwidth, and storage)

Figure 3. Carbon emissions and breakdown of emissions across generations for Apple iPhones, Watches, and iPads. Source: (Gupta et al., 2020).

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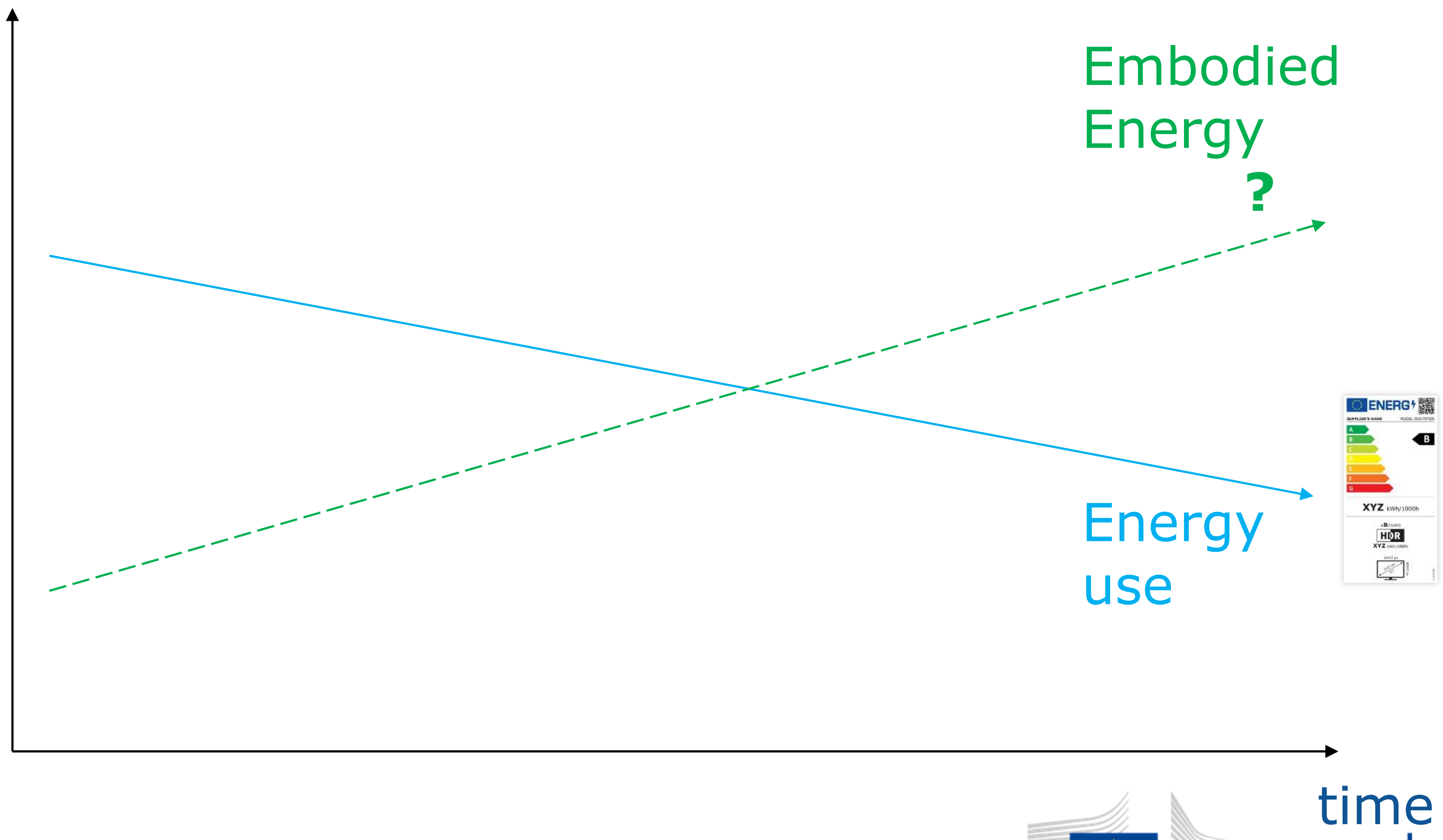
Embodied energy vs Energy Use



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Internet of Things "tornado"

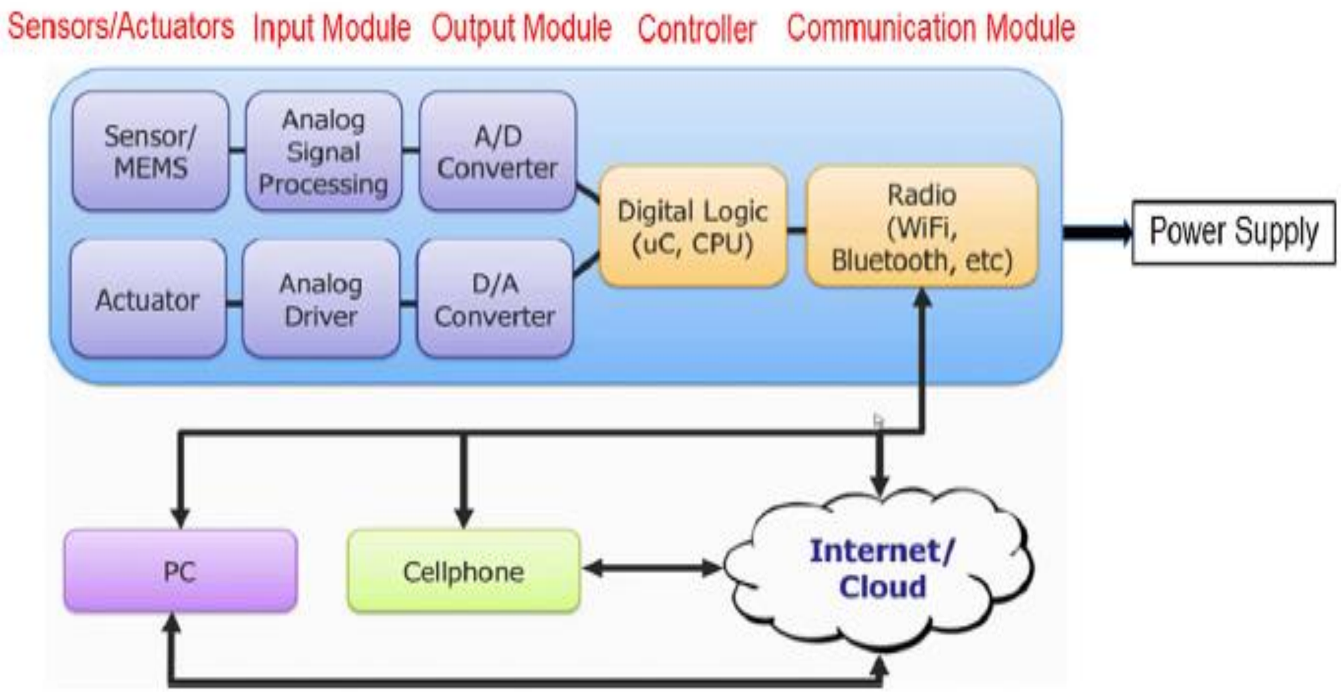

Figure 6: Schematic of an IoT device components flow in a connected economy

IoT components:

- Very Low operational energy
- Very High manufacturing energy

Internet of Things “tornado”

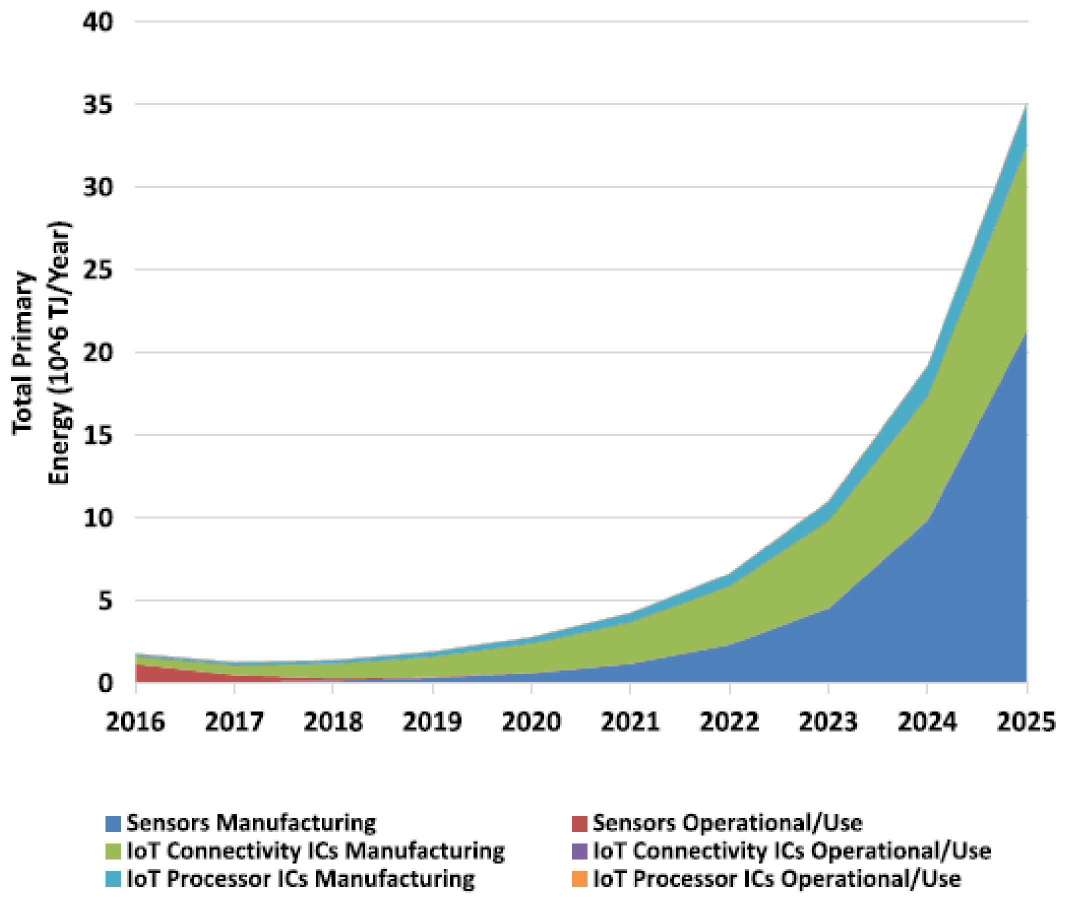

Figure 7: Global total primary energy footprint of electronics in IoT devices
Source. Das and Mao (2020).

LCA Modelling is a complex task

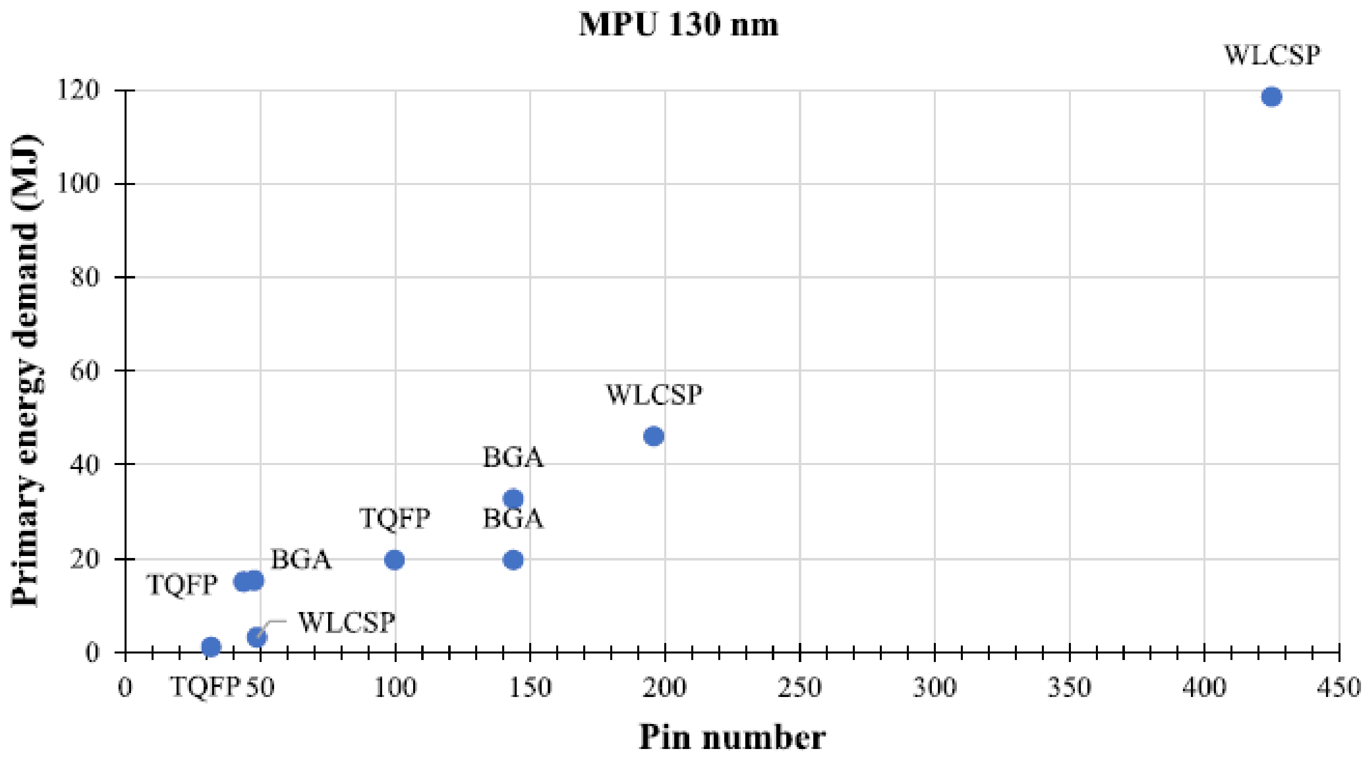

Figure 8: Primary energy demand of 130 nm MPU with different package methods. Source. Das and Mao (2020).

LCA Modelling is a complex task

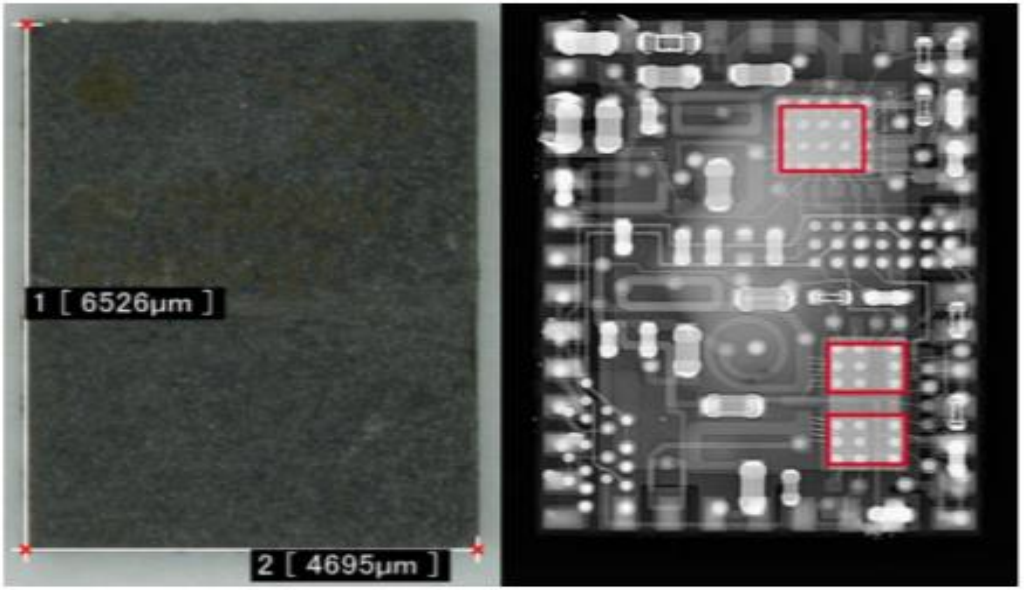

Figure 9: Photo of a packaged 3G/4G power amplifier IC from a smartphone mainboard (left) and X-ray image of the same component indicating it is a module with three smaller dies (highlighted in red boxes) and various passive components. Source: Clemm et al. 2019

Semiconductor's industry: Environmental impacts overview

IMPACTS	REPORTING	FRONT END SITES	BACK END SITES	REASON FOR IMPACT CONTROL: DESIRABLE LEVEL OF SITE RESPONSIBILITY
Toxicity in water	1	++	+++	Many dangerous chemicals are consumed; the risk of toxic effects on health and ecosystems by waste water exists
Global warming	1	+++	+++	Direct - perfluorocarbons (PFCs) - or indirect – energy - emissions The level of severity depends on the efficiency of PFC treatment units Intensive use of electricity
Resource depletion	1	+++	+++	Intensive use of raw materials
Water stress	0	+++	+	Intensive use of ultrapure water
Water Acidification	0	++	+	Many acids are consumed; the severity level depends on the sensitivity of local ecosystems and the efficiency of waste water treatment plants
Eutrophication	1	= / ++	+	Many acids are consumed; the severity level depends on the sensitivity of local ecosystems and the efficiency of waste water treatment plants
Air acidification	1	+ / ++	=	A few acidifying gases are used; the majority of emissions is controlled by air treatment units; site-dependent
Summer smog	1	++/+++	++	Emissions in air due to general plant functioning; the severity level depends on the sensitivity of local ecosystems and the efficiency of Volatile Organic Compounds (VOCs) treatment units
Human health	0	+	+	A few dangerous substances have to be managed for worker safety
Waste	1	=	+	Considerable quantity of plastic waste; variable rate of recycling
Noise	0	=	=	
Ozone layer depletion	0	=	=	
Toxicity in air	0	=	=	A few toxic gases are consumed; All are under control by air treatment units
Land occupation	0	=	=	
Toxicity (soil)	0	=	=	
Smell	0	=	=	

Table 2 Expert ranking of environmental concerns in manufacturing plants. Source: Villard et al. 2015

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Initial Remarks

- *The production of ICT devices requires energy intensive processes*
- *Increased hardware capabilities (including more IoT) can result in additional embodied energy (mainly due to the additional ICs)*
- *Modelling semiconductors in product's life cycle is complex*
- *Data on production processes and associated impacts are still limited*

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Second order effects

Induction:

Energy use in data centres and telecommunication network

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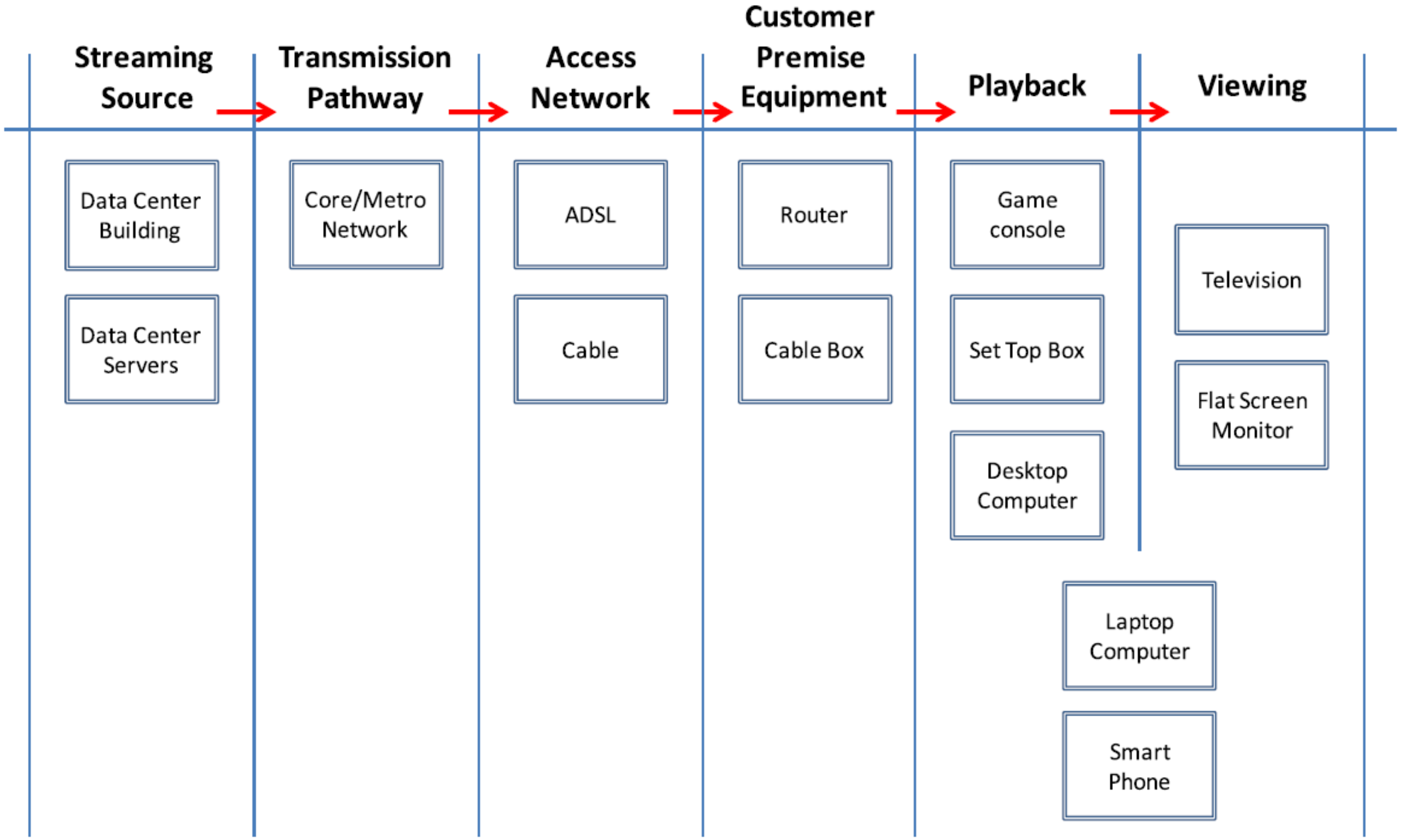
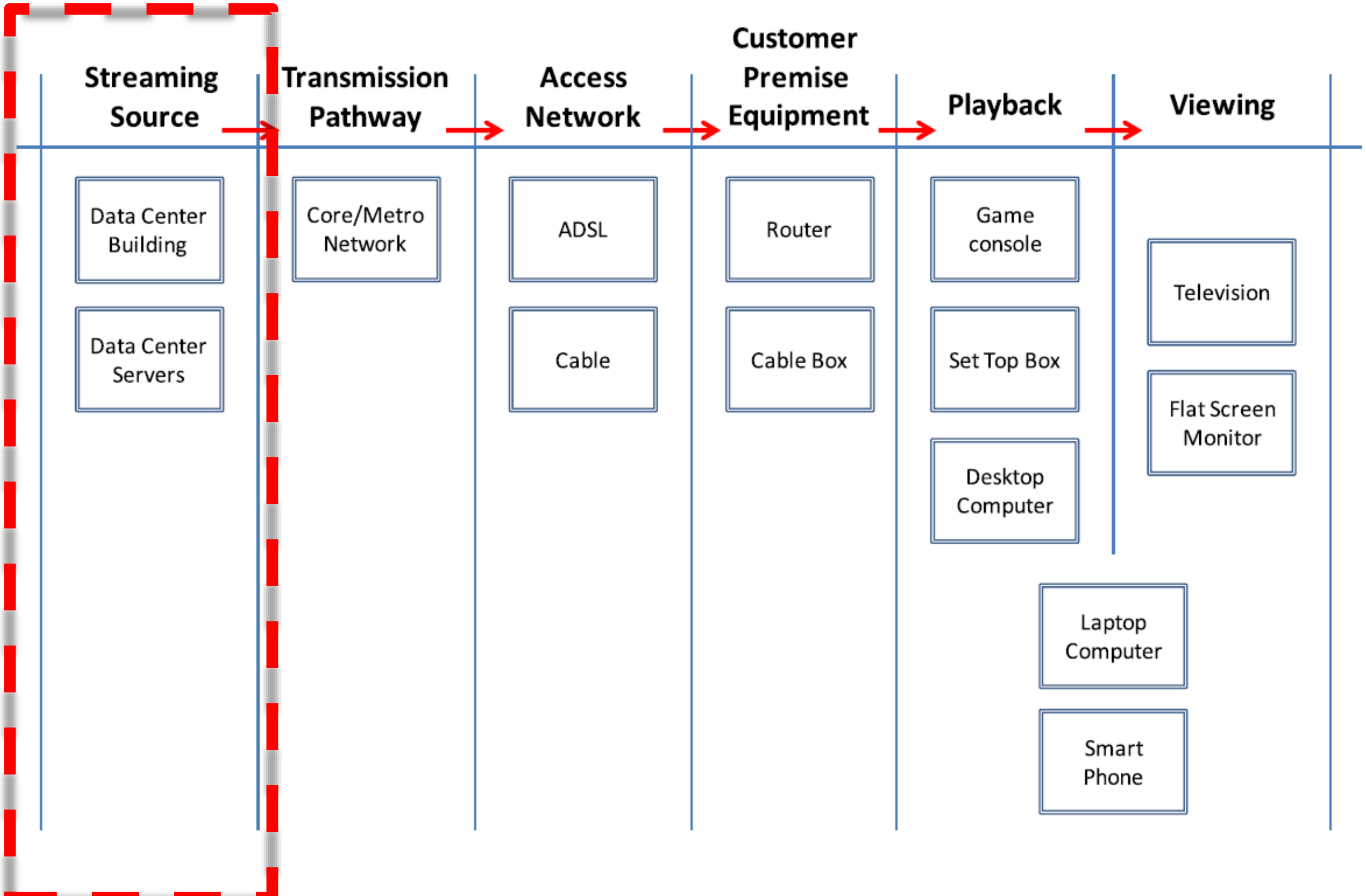
Whose energy consumption?



ICT system devices and processes used to provide a streaming video service to a viewer. Source: Shehabi et al 2014.

Whose energy consumption?



ICT system devices and processes used to provide a streaming video service to a viewer. Source: Shehabi et al 2014.

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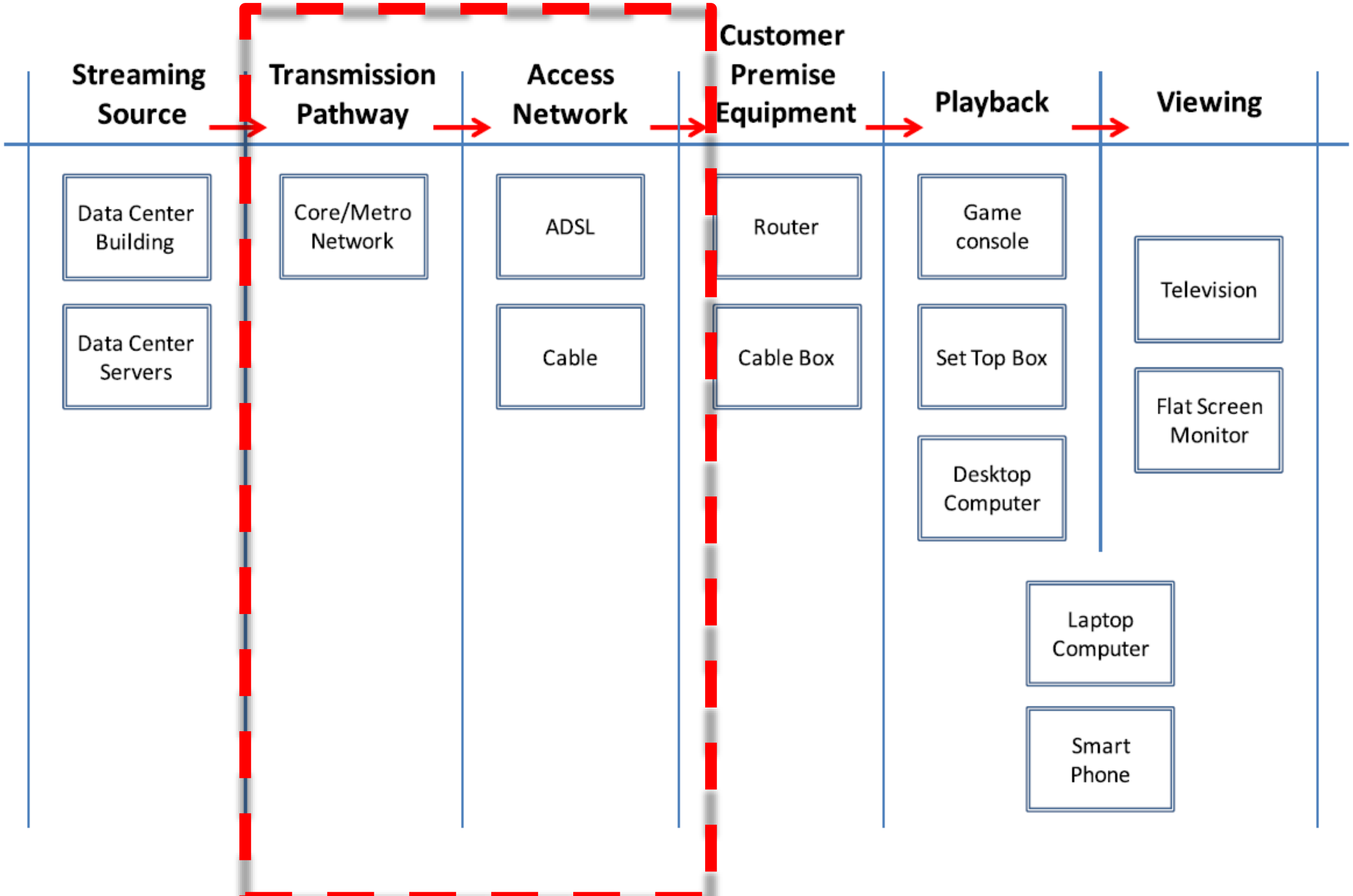
Whose energy consumption?



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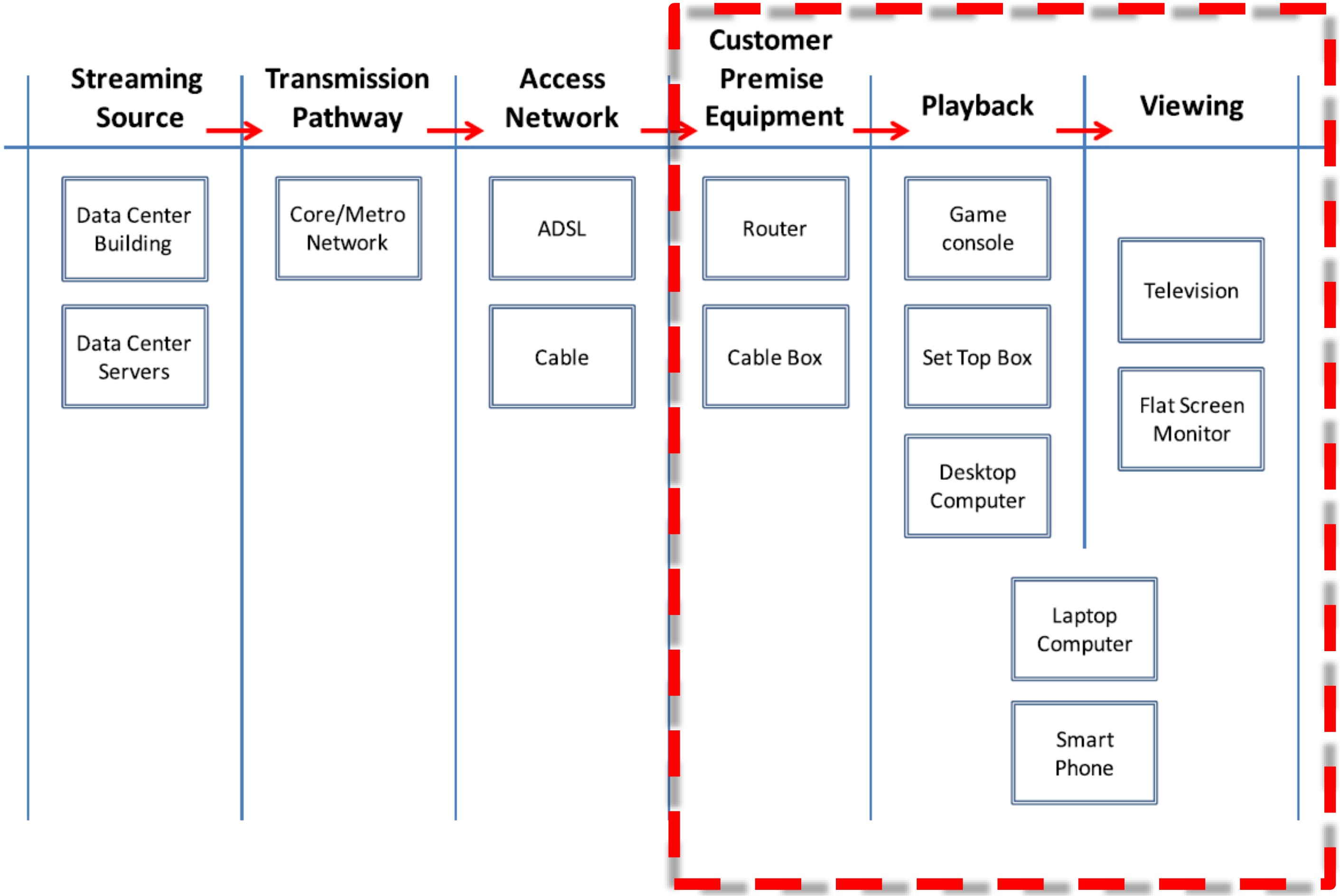
Whose energy consumption?



ICT system devices and processes used to provide a streaming video service to a viewer. Source: Shehabi et al 2014.

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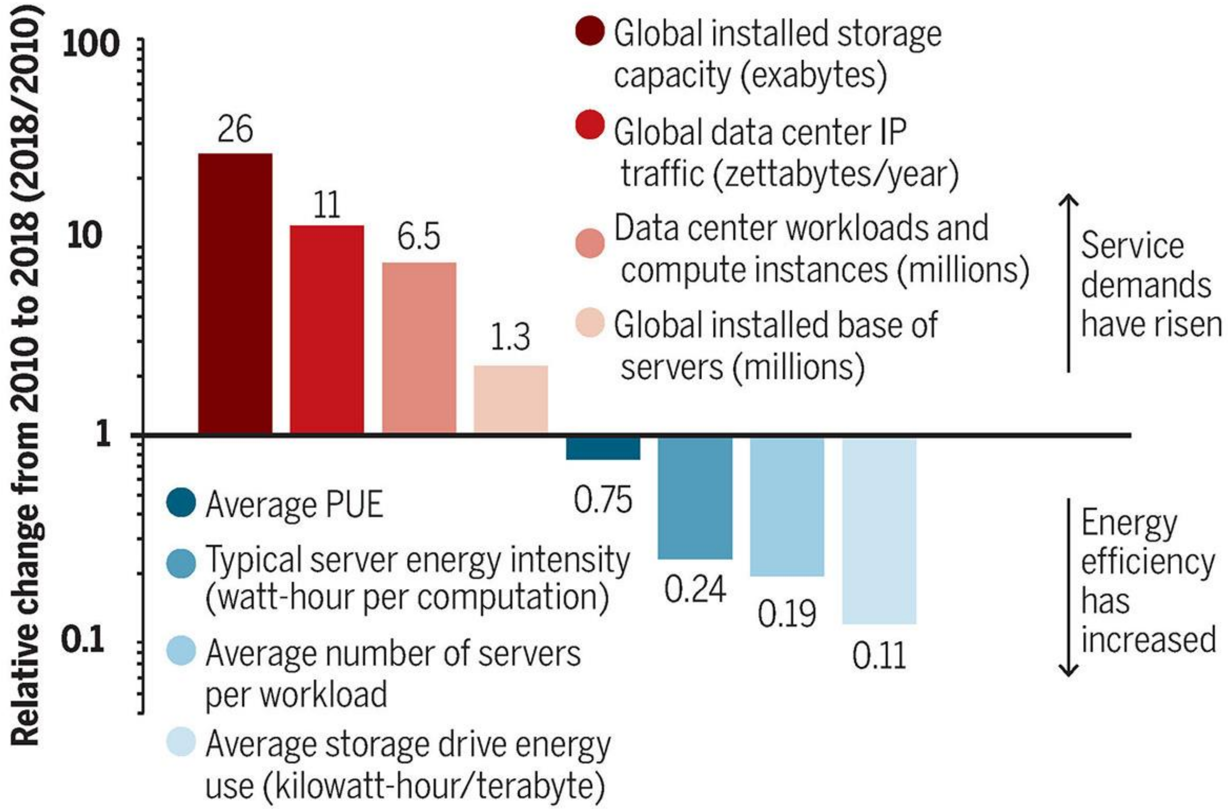
Trends in ICT system energy use



PUE, power usage effectiveness; IP, internet protocol.

Source: Masanet et al 2020

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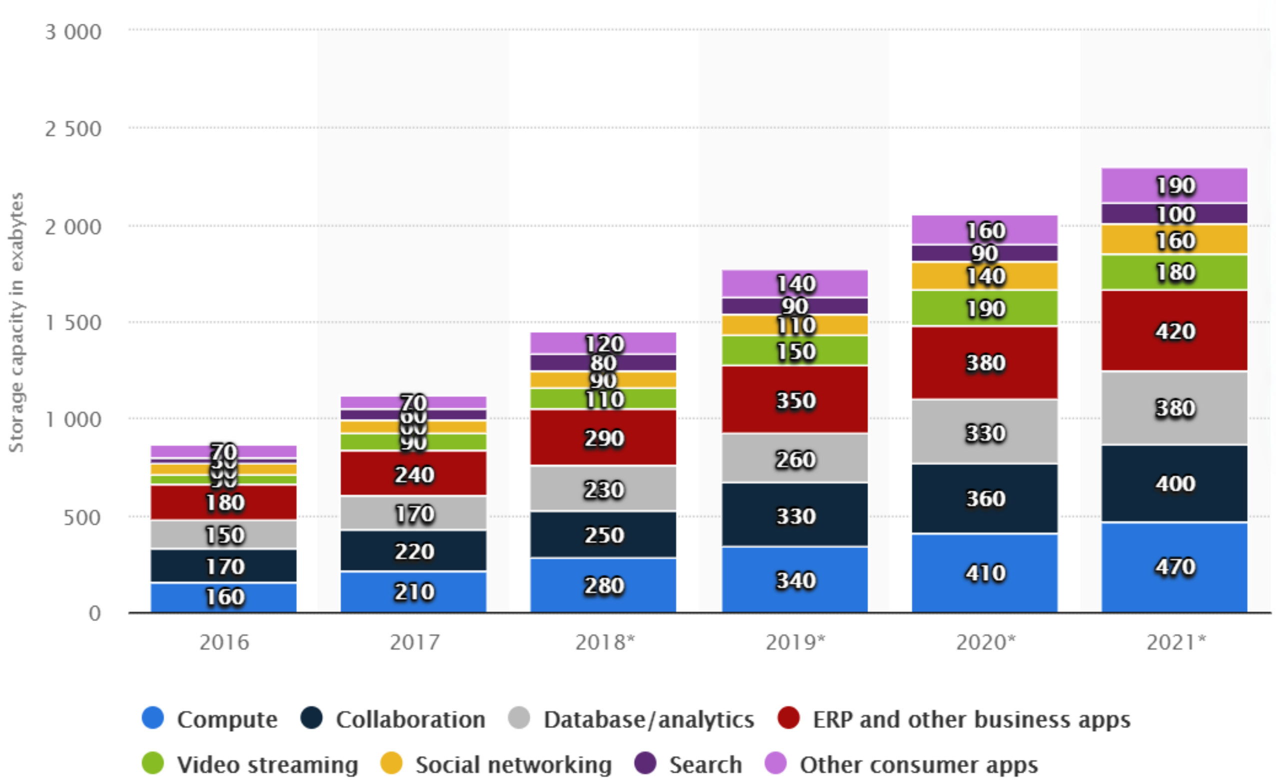
Data centres – storage capacity



Trends in the installed storage capacity in exabytes
Source: Statista, 2021

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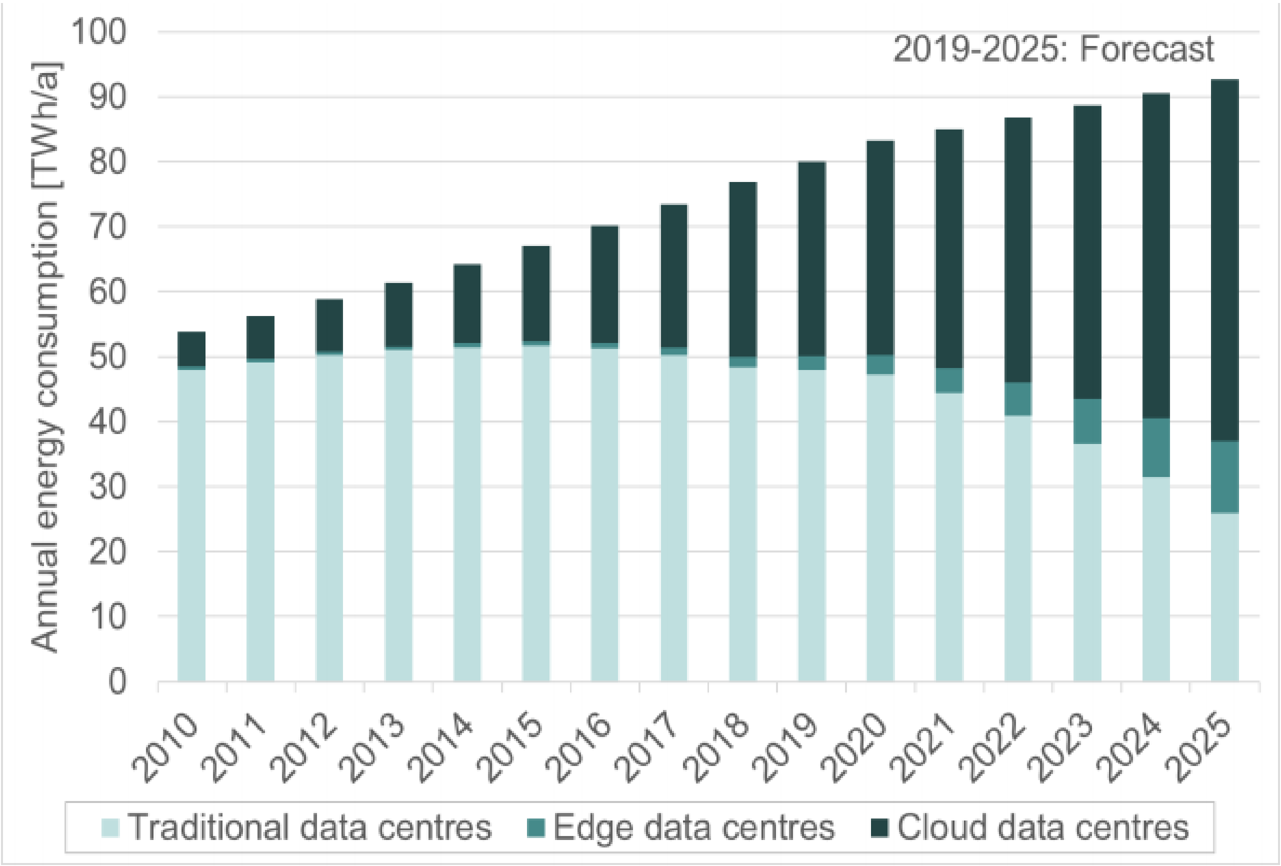
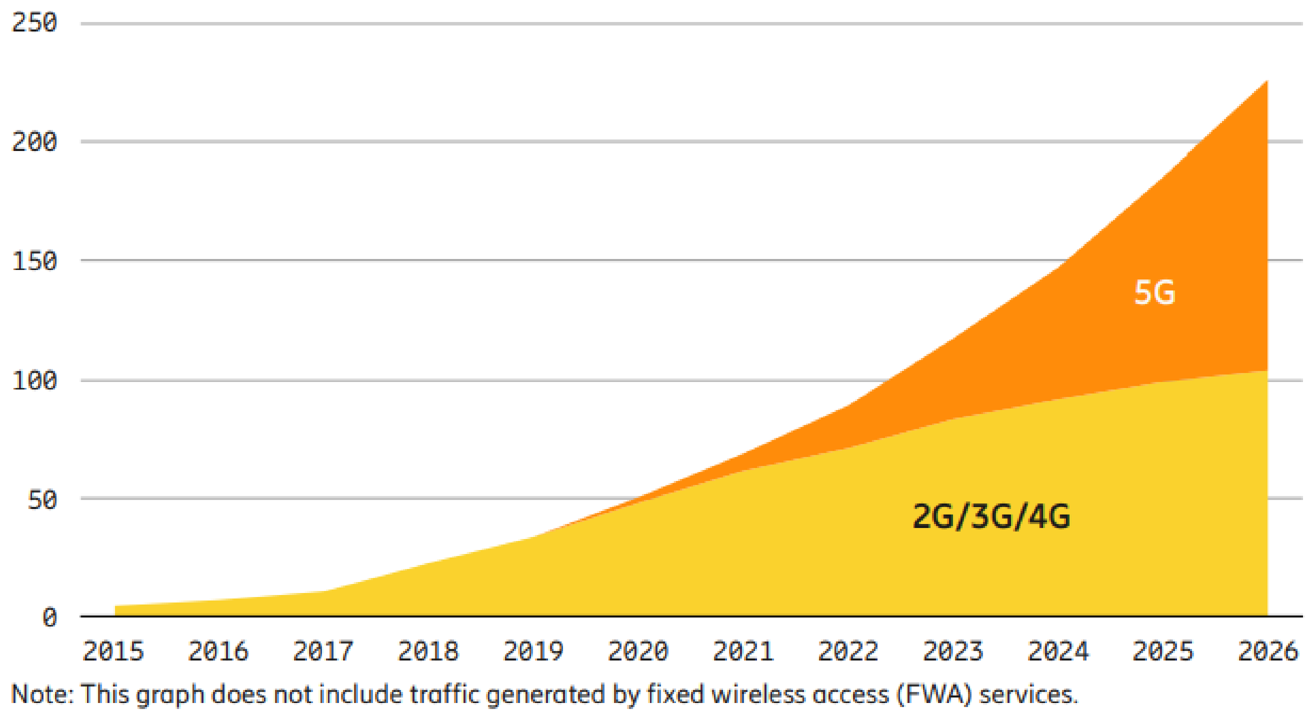
Data centres – type



Trends and forecasts in terms of energy consumption by data centre type in **EU28**. Source: Montevecchi et al (2020)

Network – increased data traffic



Trends and forecasts for global mobile data traffic (Exabytes per month). Source: Ericsson (2020)

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Network – increased speeds

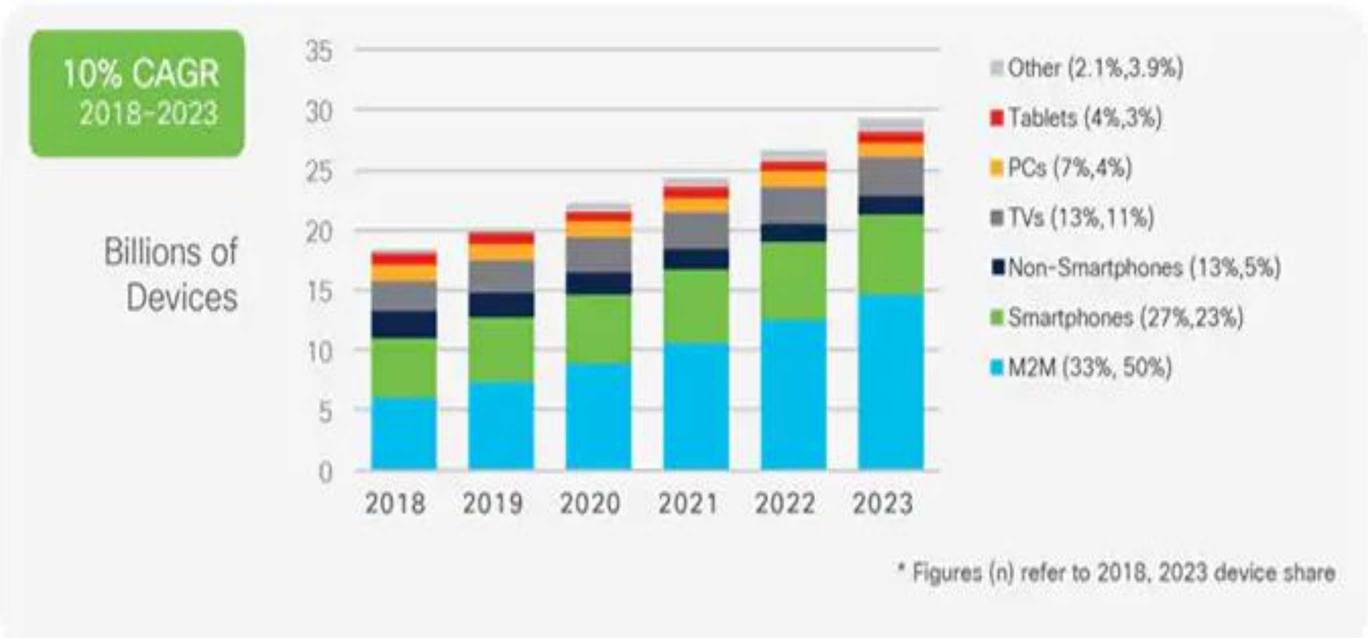
Region	2018	2019	2020	2021	2022	2023
Global	45.9	52.9	61.2	77.4	97.8	110.4
Asia Pacific	62.8	74.9	91.8	117.1	137.4	157.1
Latin America	15.7	19.7	34.5	41.2	51.5	59.3
North America	56.6	70.1	92.7	106.8	126.0	141.8
Western Europe	45.6	53.2	72.3	87.4	105.6	123.0
Central and Eastern Europe	35.0	37.2	57.0	65.5	77.8	87.7
Middle East and Africa	9.7	11.7	25.0	29.0	34.9	41.2

Fixed broadband speed (Mbps). Source: Cisco (2020)

Region	2018	2019	2020	2021	2022	2023
Global speed: All handsets	13.2	17.7	23.5	29.4	35.9	43.9
Asia Pacific	14.3	18.0	24.7	32.4	39.0	45.7
Latin America	8.0	11.2	15.7	21.1	24.8	28.8
North America	21.6	27.0	34.9	42.4	50.6	58.4
Western Europe	23.6	31.2	40.1	48.2	54.4	62.4
Central and Eastern Europe	12.9	15.7	21.3	30.3	36.1	43.0
Middle East and Africa	6.9	9.4	13.3	17.6	20.3	24.8

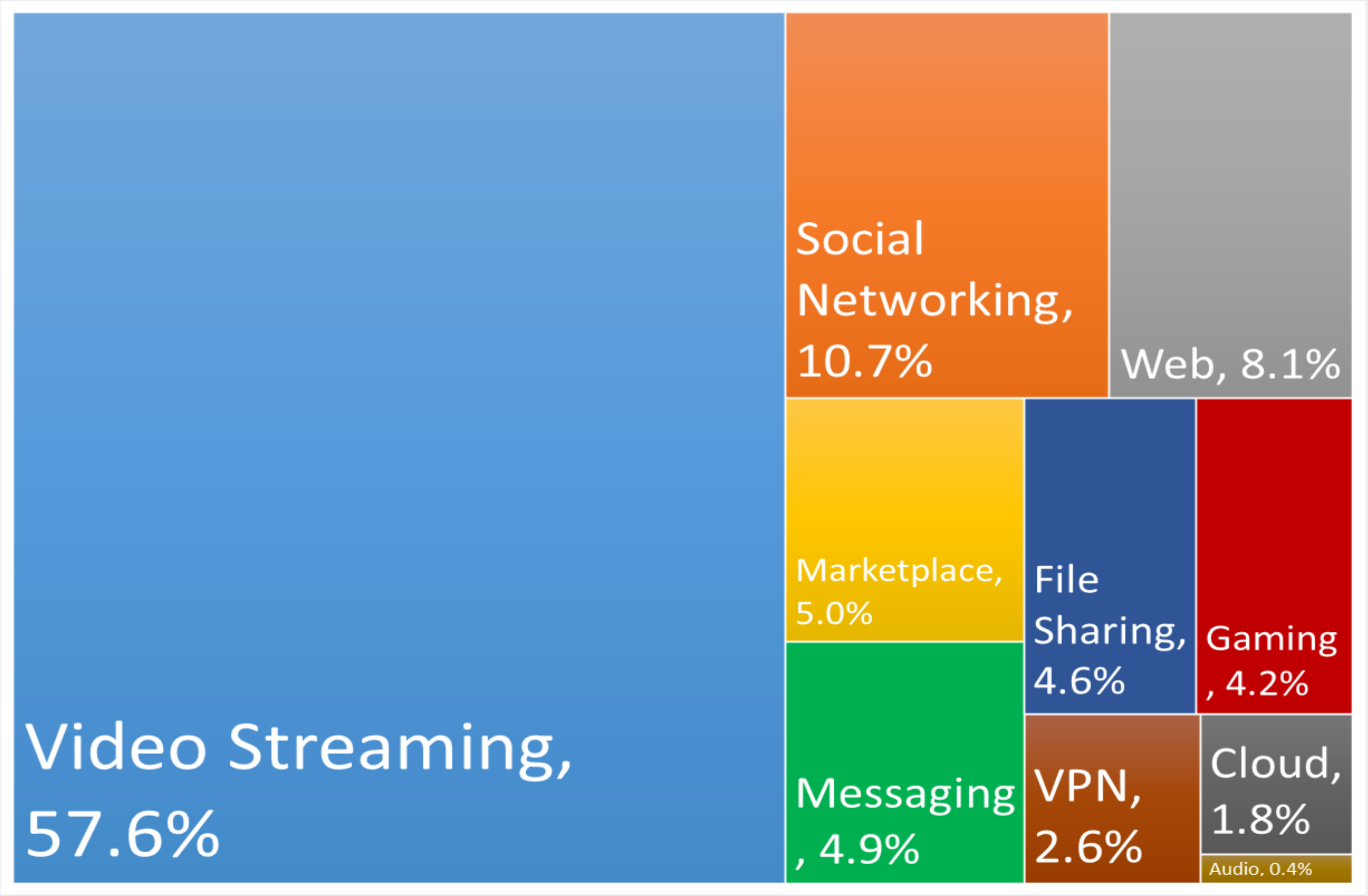
Mobile network connection speed (Mbps). Source: Cisco (2020)

Consumer Devices – number of connections



Number of connected devices. Source: Cisco (2020)

Consumer Devices – applications



Global Application Category Total Traffic Share, Source: Sandvine 2020

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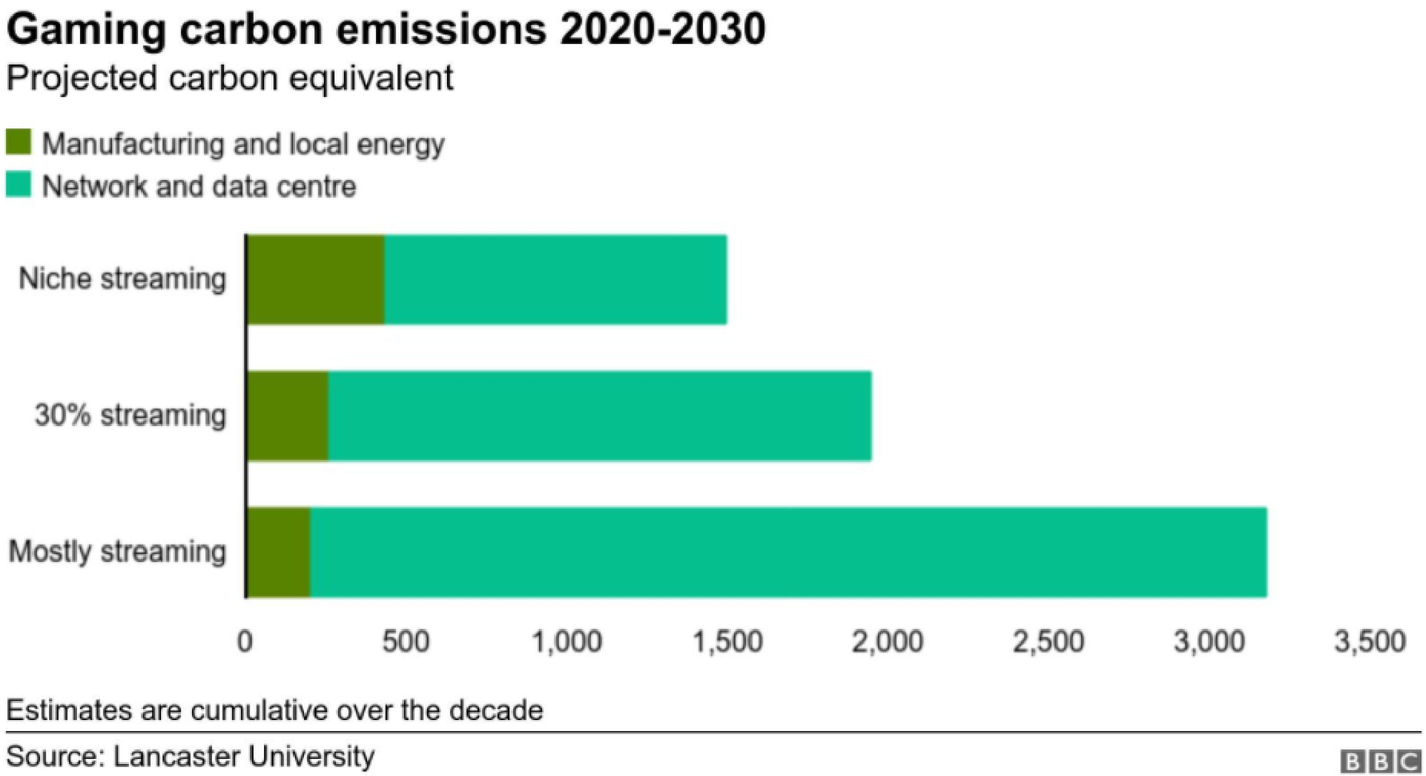
Consumer Devices – device characteristics

Increasing video definition. By 2023, 66% of connected flat panel TV sets will be 4K. Source: Cisco 2020

Consumer Devices



Energy use remarks

- *Energy use difficult to forecast due to methodological challenges, system complexity, fast-paced innovation*

- *Overall energy use determined by the scale of efficiency vs data demand growth*

- ***Data centres**: energy use driven by increased storage capacity and computing*

- ***Network**: energy use driven by increased data traffic (via increased speed)*

- ***Consumer devices**: energy use driven by number of connected devices, and device characteristics*

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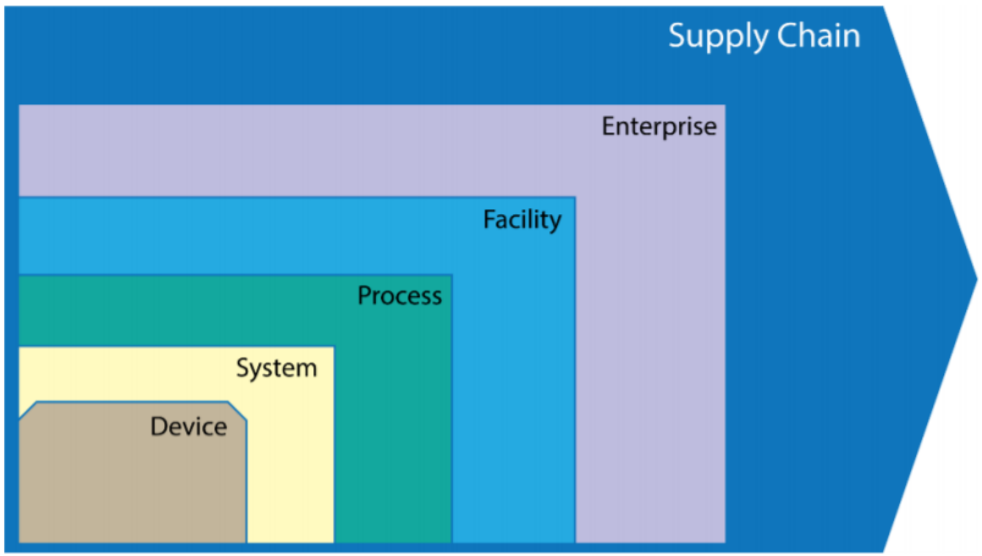
Second order effects

Optimisation and substitution:

Contribution of ICT to energy efficiency in systems

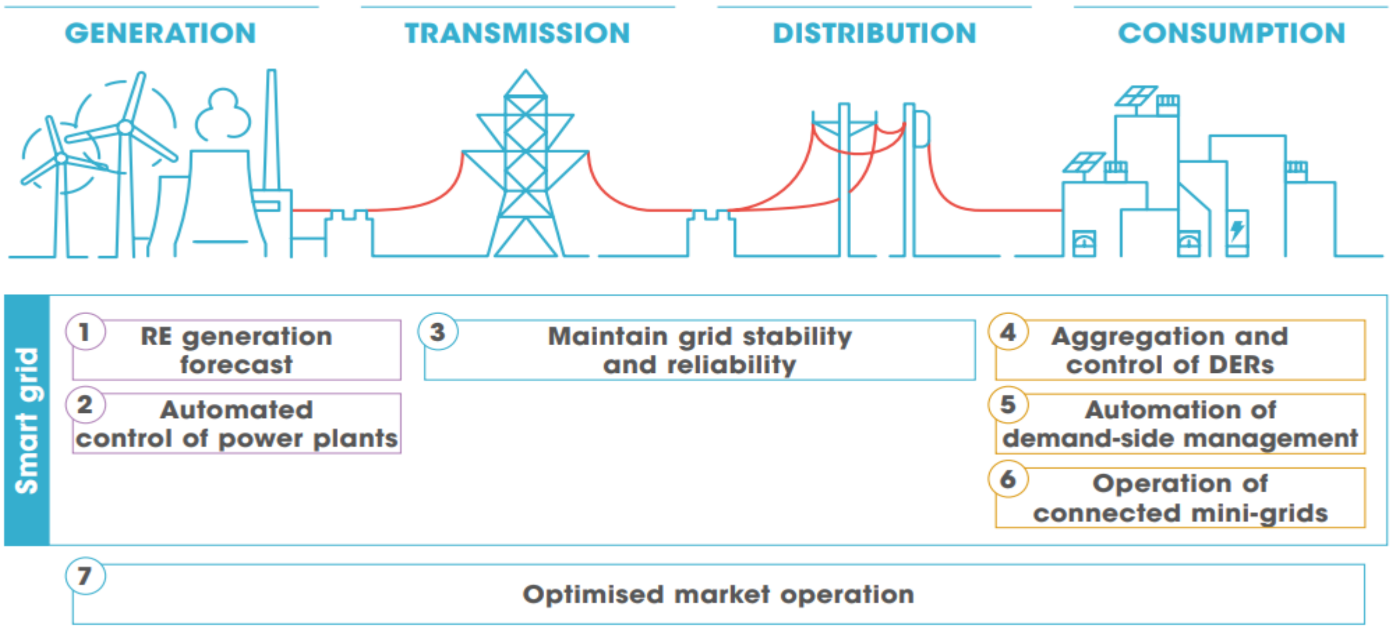
Industry / Production Management



The optimization optimisation opportunities go beyond the equipment level and include system and process levels (machine scheduling, environmental conditions, resources assignment, operation planning).

Figure 36: Order of energy savings in manufacturing. Source: Rogers (2014)

Optimisation of Energy systems: matching demand and supply



DER = distributed energy resources
Source: IRENA, IRENA, adapted from BNEF, 2017

IoT Optimisation in home/office

BAC system product	Components providing data input
heating, ventilation (including window openings) and air conditioning (HVAC)	Temperature sensors
domestic hot water (DHW)	CO_2 sensors
solar shades	Humidity sensors
lighting	Presence detectors
electrical power distribution	Solar radiation sensors
access control & security	Outdoor wind speed meter
fire safety	Light meter
	Domestic cold and hot water meters
	Electricity meters
	Heat and other energy meters
	Door and window opening sensors
	Smoke and fire detectors
	Access control detectors
	User setting for desired indoor quality level, scheduling

Table 14: Building Automation and Control (BACS) products and related components / sensors providing data inputs

Energy Harvesting

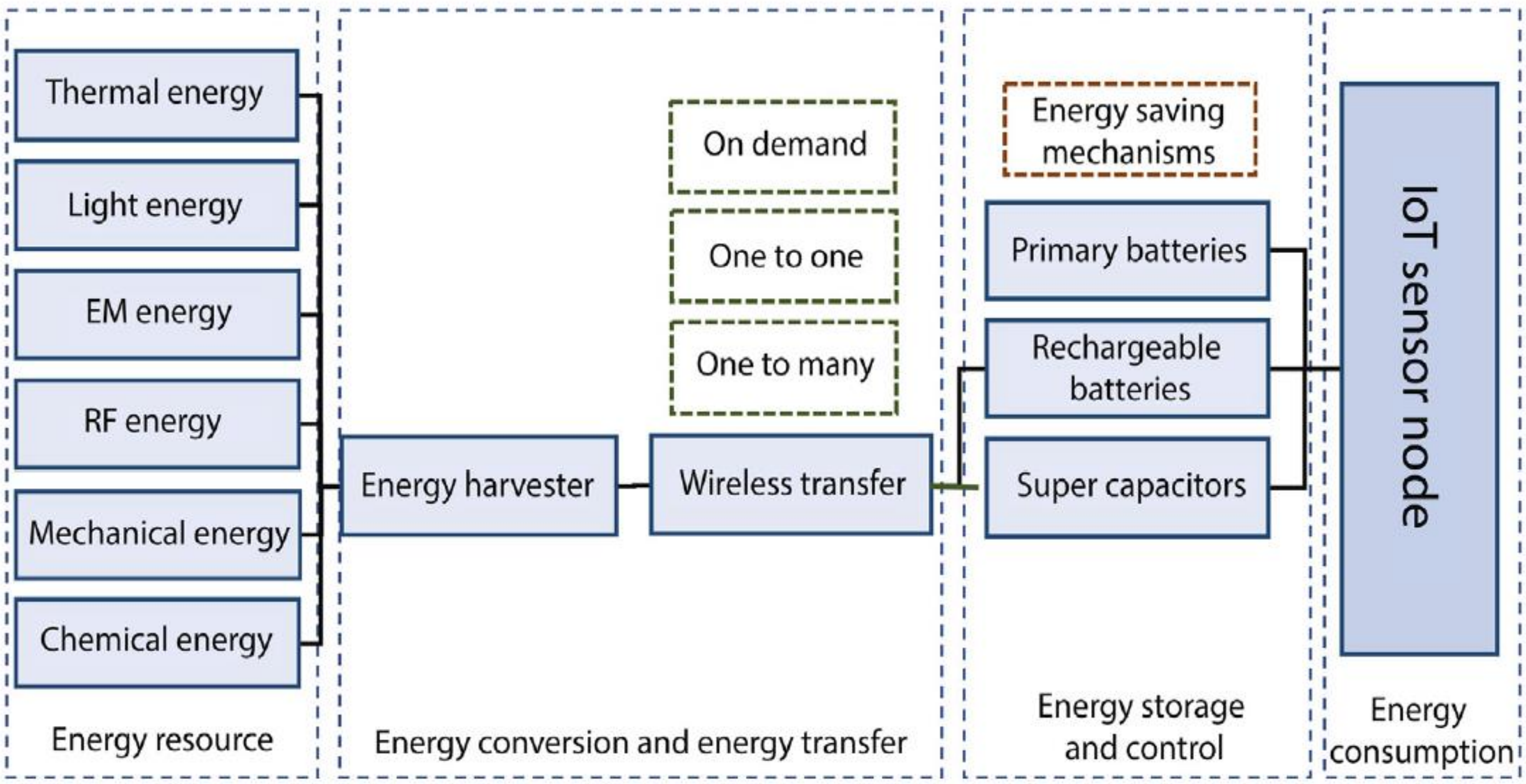


Figure 43: A block diagram of an energy harvesting system. Source: Zeadally et al 2020.

Challenges of ICT

- The generation and submission of large amounts of data and the impact on the ICT system that this entails.

- The “sensor’s tornado” and the associated manufacturing impacts

- Optimisation effects can be incomplete or cancelled out by rebound effects

Task 3
Questions / Comments?

Next steps

Task 1 - *Creation of project website, initial list of stakeholders, launch of an initial awareness message*
Task 2 - *Consolidation of the definition and categorisation of the different sectors/products analysed under 'ICT products'*
Task 3 - *Potential for Energy Savings*
Task 4 - *Material Efficiency: Collection of data*
Task 5 - *Analysis of potential for material efficiency*
Task 6 - *Analysis of trade-offs and synergies*
Task 7 - Analysis of user behaviour implications
Task 8 - *Grouping of products*
Task 9 - *Analysis of the Life cycle costing implications*
Task 10 - *Comprehensive compilation of possible policy instruments for ICTs products*
Task 11 - *Suitability for different policy instruments*
Task 12 - *Final Policy Recommendations.*

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Task 7 - Analysis of user behaviour implications

Consumers survey (with the support of IPSOS):

- **how the performance of internet audio/video multimedia affects the consumer purchase decision of ICT devices**
- **use of ICT devices for internet multimedia – correlation between type of media, type of connection and type of device**
- **the relevance of factors such as energy and material efficiency in the purchase decisions of consumers**
- **7 EU Countries, 1000 completed interview per country, different age, genders, level of education and employment**

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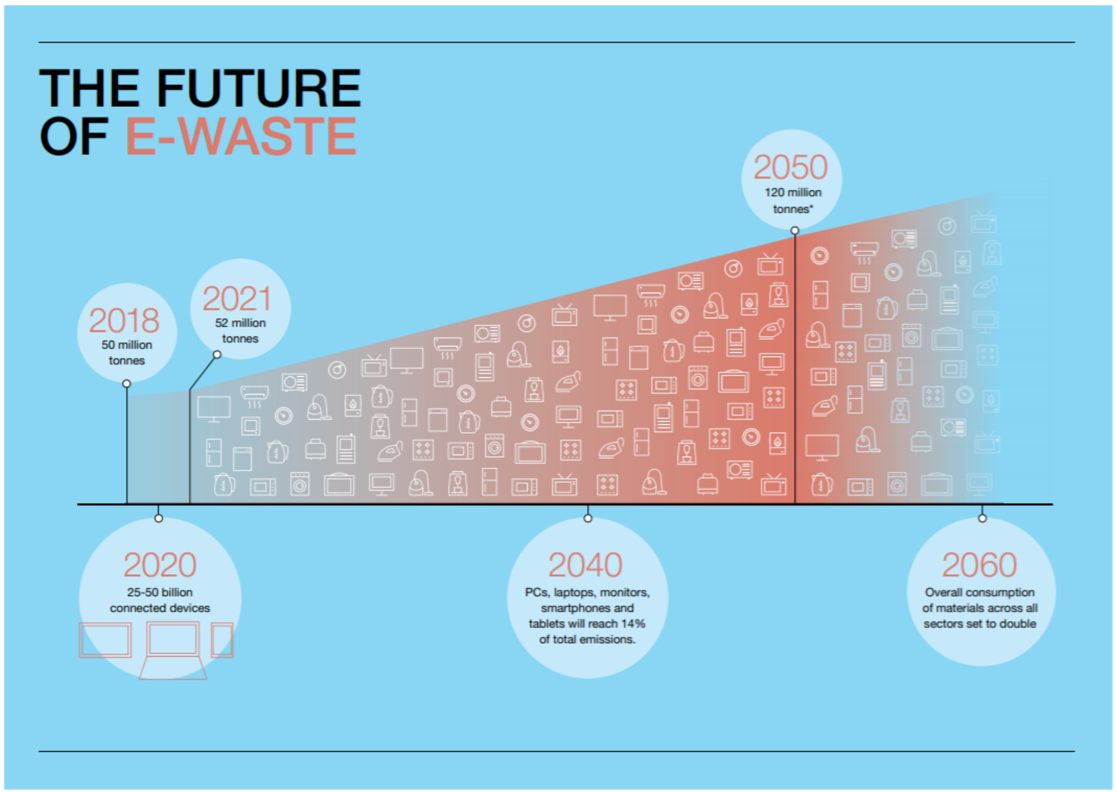
Additional slides

ICT Impacts on Sustainability

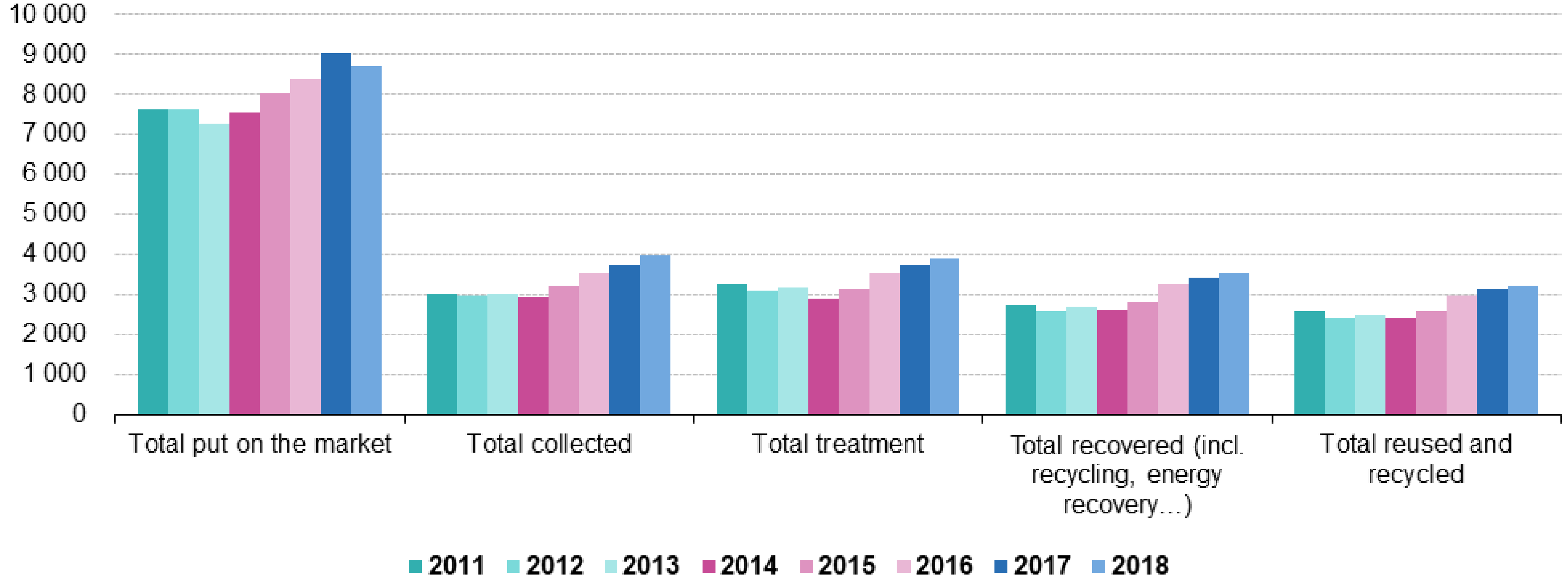


PACE (Platform for Accelerating the Circular Economy) and World Economic Forum (2019). New Circular Vision for Electronics - Time for a Global Reboot.

European Commission

Electrical and electronic equipment (EEE) put on the market and waste EEE collected, treated, recovered, recycled and prepared for reuse, EU, 2011–2018

(thousand tonnes)

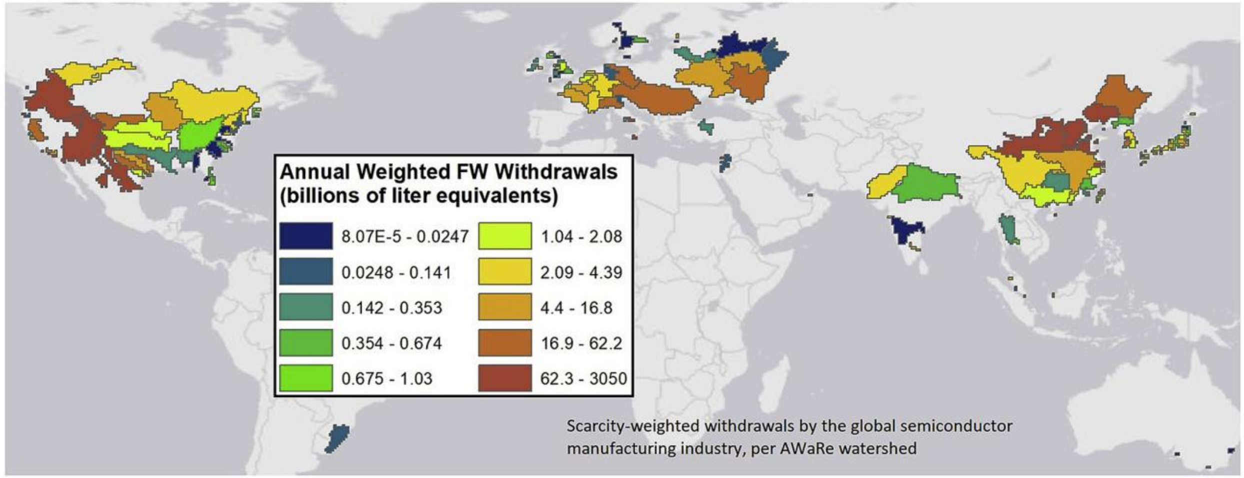


Note: 2016, 2017 and 2018 data, as well as 2011 data for reused and recycled EEE waste: Eurostat estimates

Source: Eurostat (online data code: env_waselee)

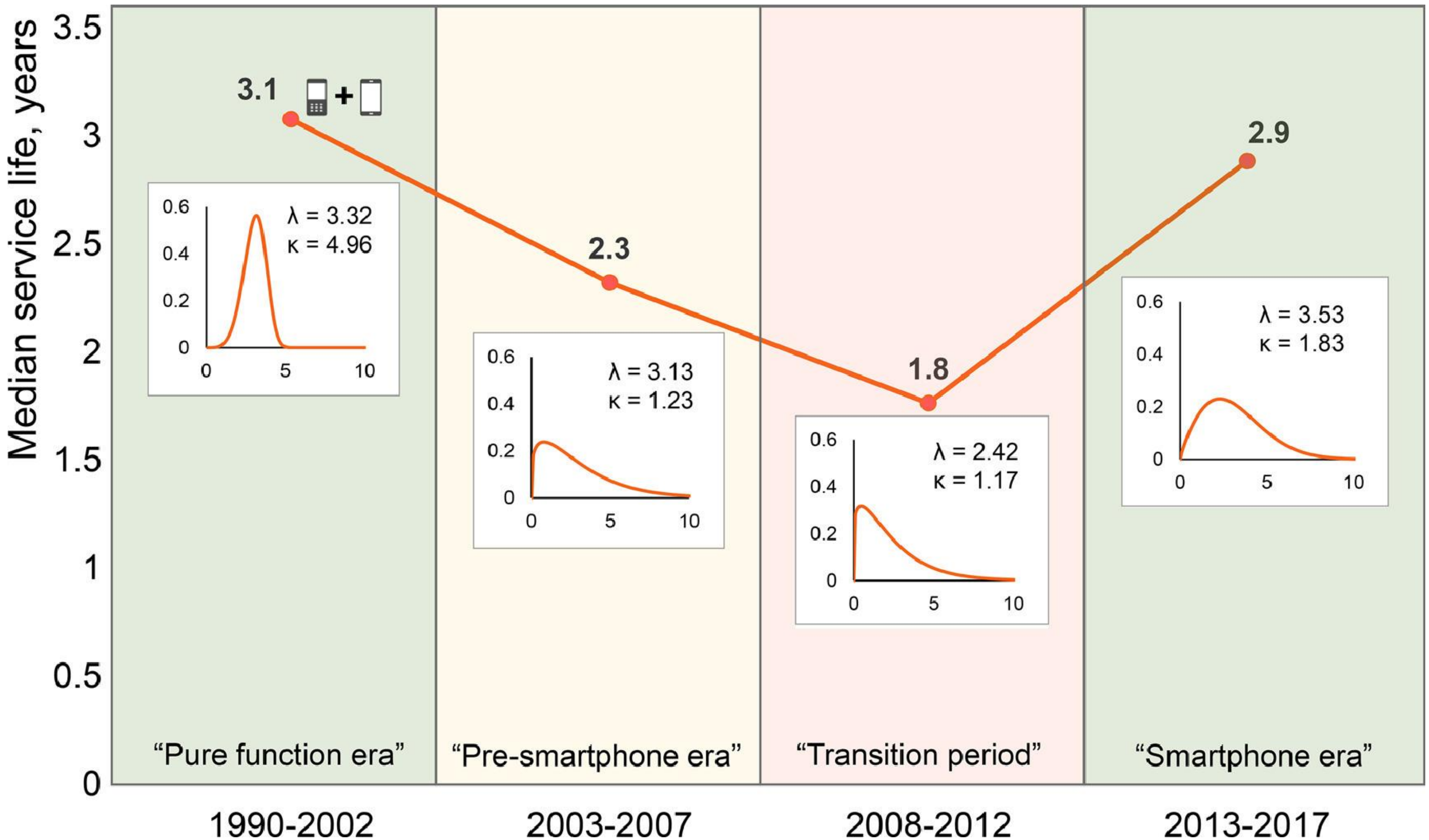
eurostat

European Commission



Scarcity-weighted withdrawals by the global semiconductor manufacturing industry, per AWaRe watershed

Example of obsolescence effect due to short technological cycles



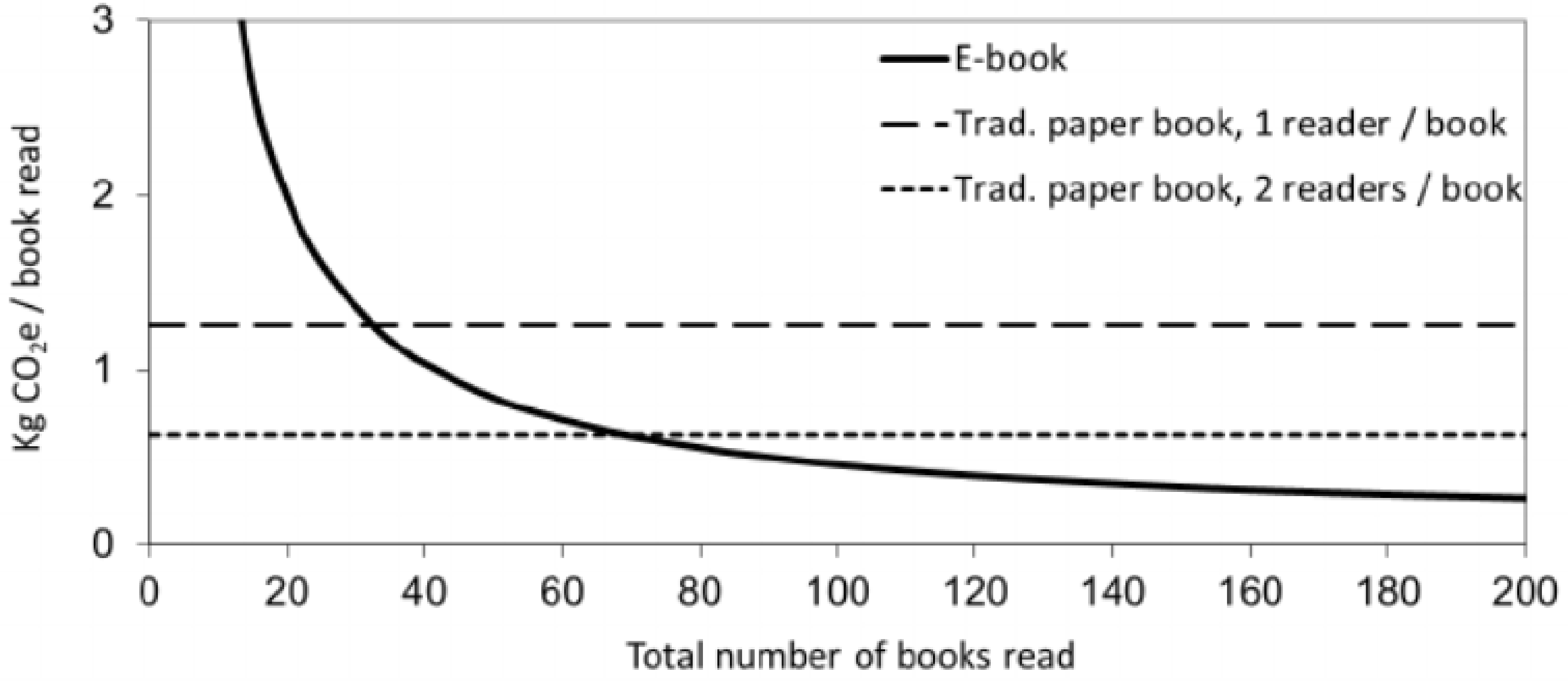
European Commission

Example of induction effect

Higher resolution video streaming

Quality	Resolution	Video Bitrate
HD 720	1280x720	1,200 - 4,000 kbps
HD 1080	1920x1080	4,000-8,000 kbps
4K	3840x2160	8,000-14,000 kbps

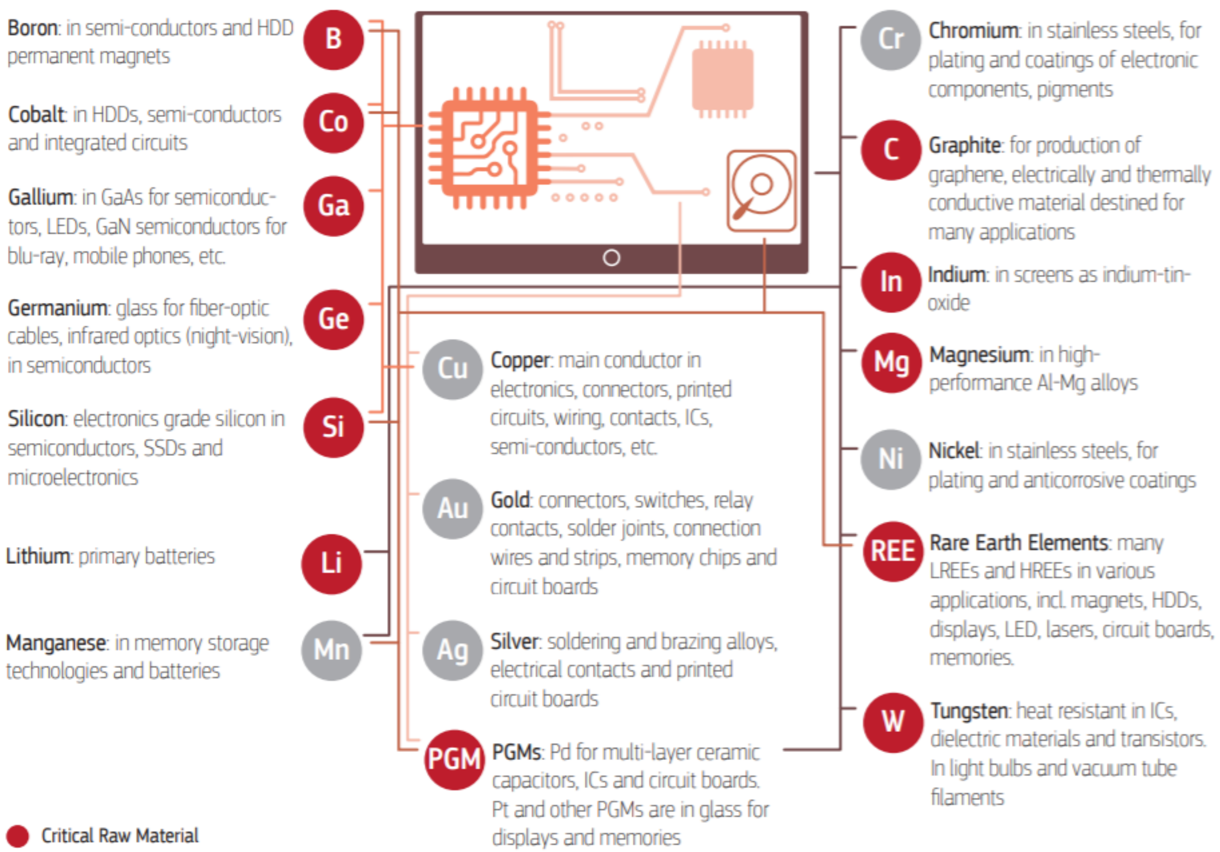
Example of substitution effect



European Commission

Raw materials in digital technologies

Figure 44. Raw materials in digital technologies.



Source: (BCG, 2018).