Sustainable ICT assessment, adoption and strategy

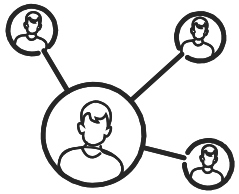
T Ernst

ICOS 26/04/2023

DATA DRIVEN AREA
EVOLUTION WITHIN 10 YEARS 2010 - 2020

World population

+11%



Internet users

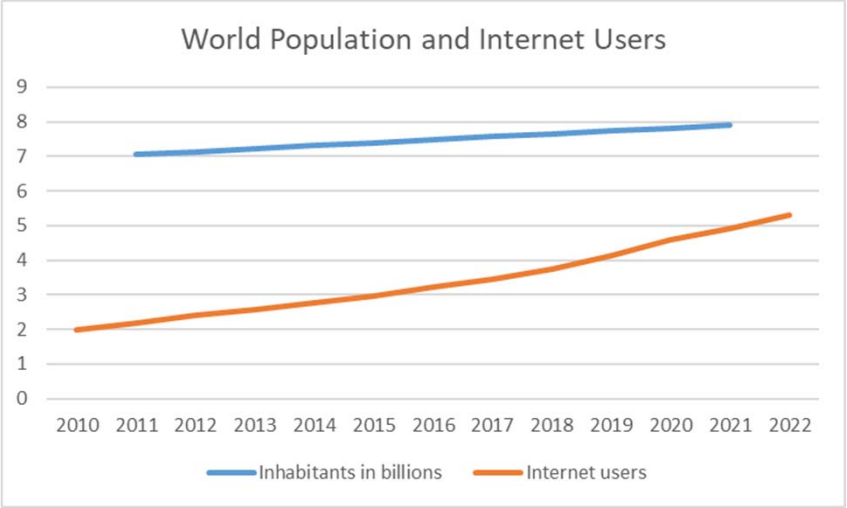
+135%

Electricity

+28%

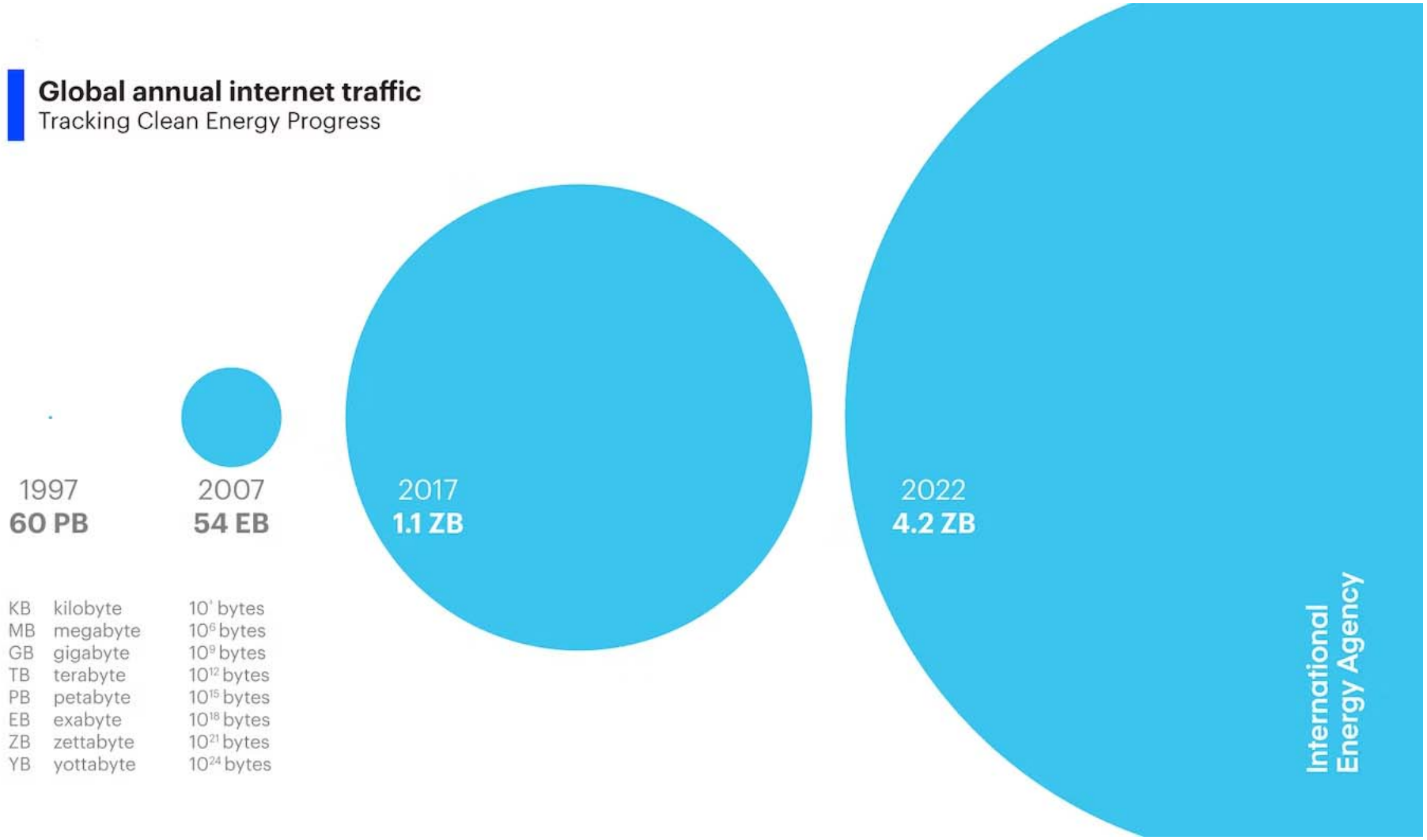
X14 Mobile users in Africa

(Source : Statista)



Global annual internet traffic

Tracking Clean Energy Progress



KB	kilobyte	10^3 bytes
MB	megabyte	10^6 bytes
GB	gigabyte	10^9 bytes
TB	terabyte	10^{12} bytes
PB	petabyte	10^{15} bytes
EB	exabyte	10^{18} bytes
ZB	zettabyte	10^{21} bytes
YB	yottabyte	10^{24} bytes

3 POSITIVE IMPACTS OF ICT

1. EDUCATION / INFORMATION ACCESS FOR MOST

2. CONNECTION HELPS EXCHANGES

   AND DEVELOPPEMENT

3. MEASURING, MODELLING, UNDERSTANDING OUR IMPACT

giec

Life Cycle Analysis (LCA)

3 NEGATIVE IMPACTS OF ICT

1. ENERGY CONSUMPTION

Fabrication ≥ Use !!!!!
55 % of worldwide electricity is carbonated (coal-gas-etc) source IEA

2. ECOLOGICAL IMPACT ON ECOSYSTEMS

3x Mining activities due to energy transition

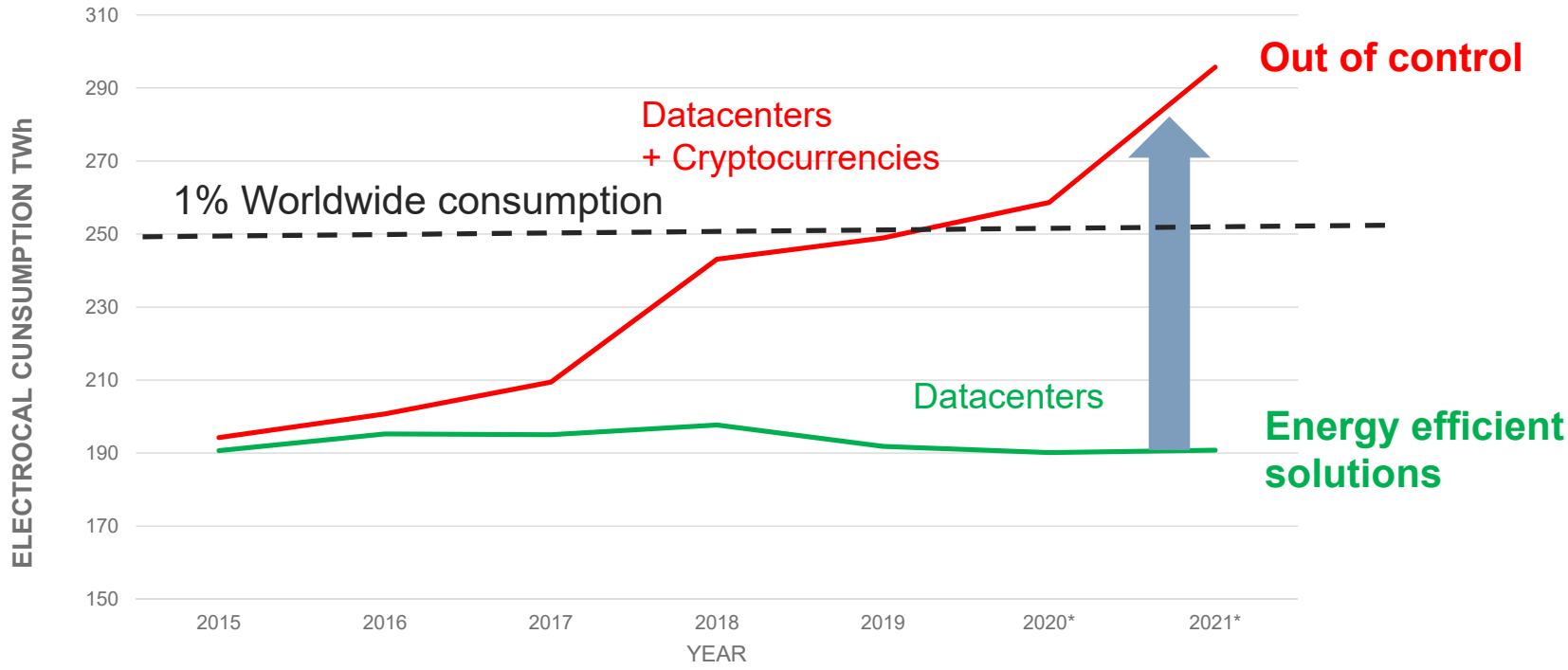
Next 35 years will need more than all our history

Source: www.systext.org

3. GEOSTRATEGIC DEPENDENCIES

China controls most refining of Co, Ni, Li and

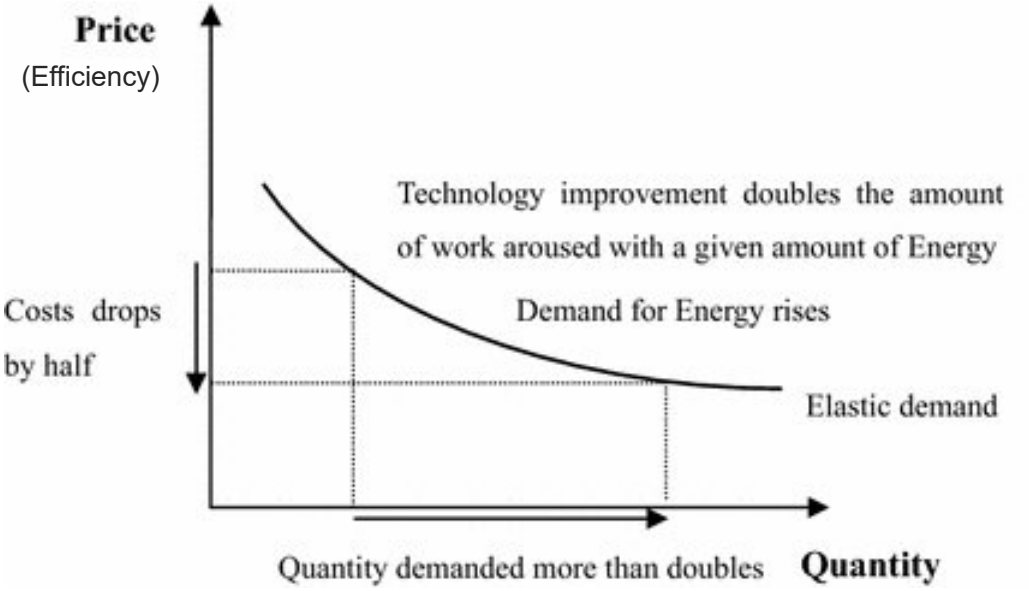
Datacenters vs Cryptocurrencies electrical consumption (Use only !)



Worldwide energy consumption in 2021: 25 000 TWh

JEVONS PARADOX (REBOUND EFFECT)

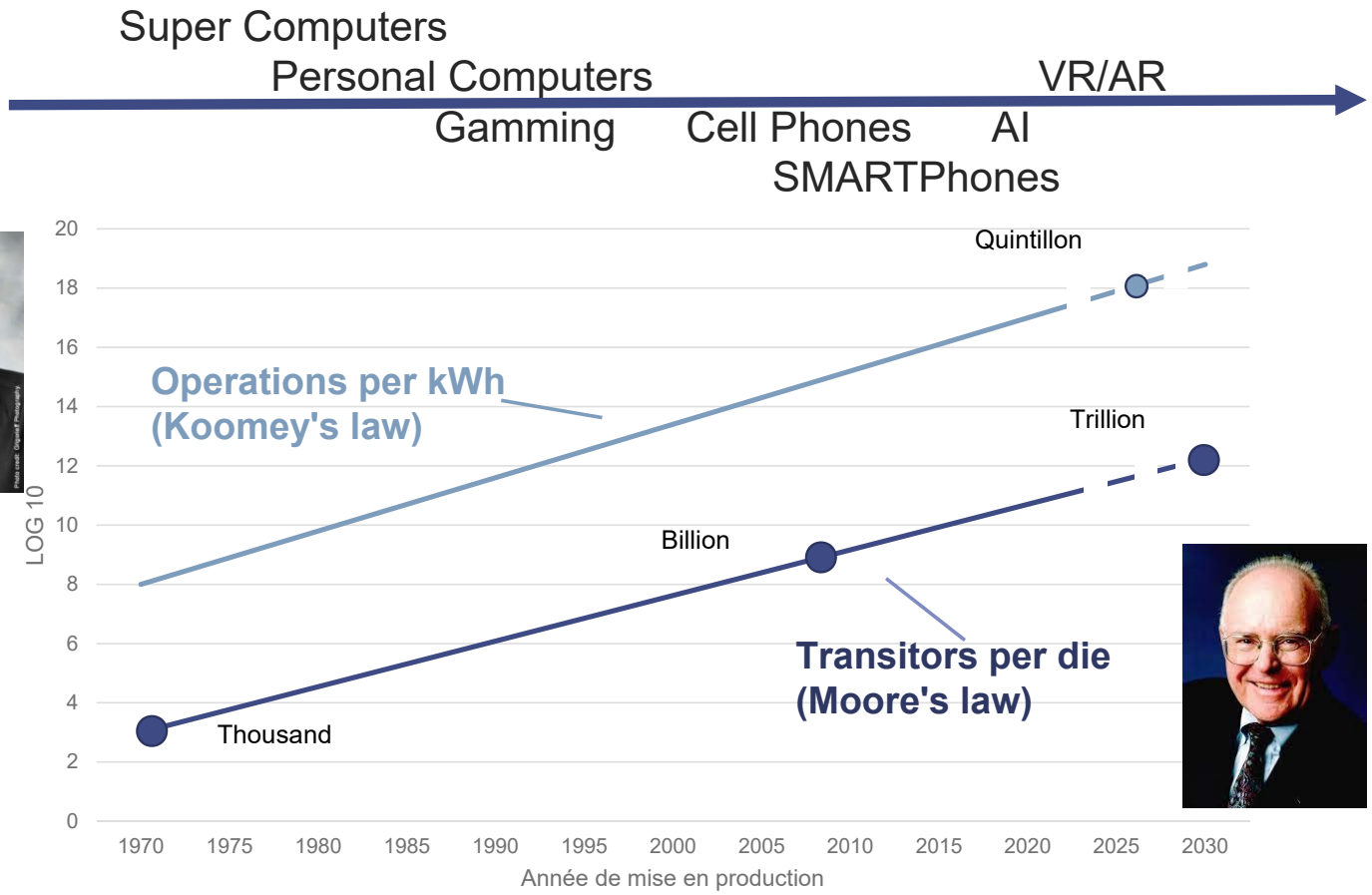
W. S. Jevons



M. Lu et al, Ann Oper Res (2017) 255:525–546

.... Jevons paradox is not a fatality .... But should be anticipated !

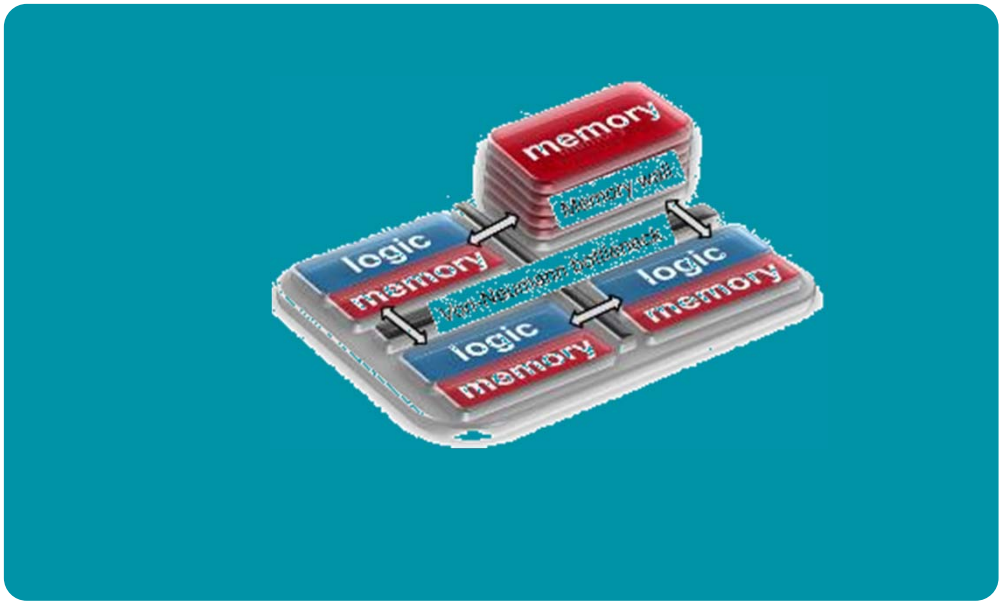
SCALING- ENERGY EFFICIENCY AND APPLICATIONS



GAIN IN ENERGY EFFICIENCY IN 50 YEARS = 100 000 000 !!!

ENERGY EFFICIENCY – LESS DATA MOVES TOWARDS THE ULTIMATE IN-MEMORY-COMPUTING

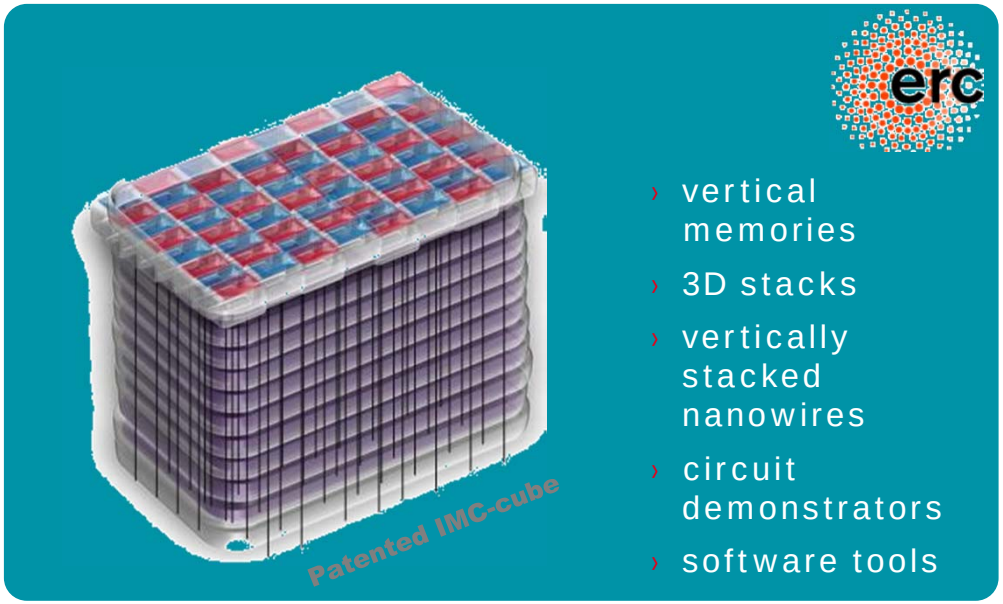
Today



Problem:
Energy-efficiency in data-abundant

integrated circuits

Tomorrow

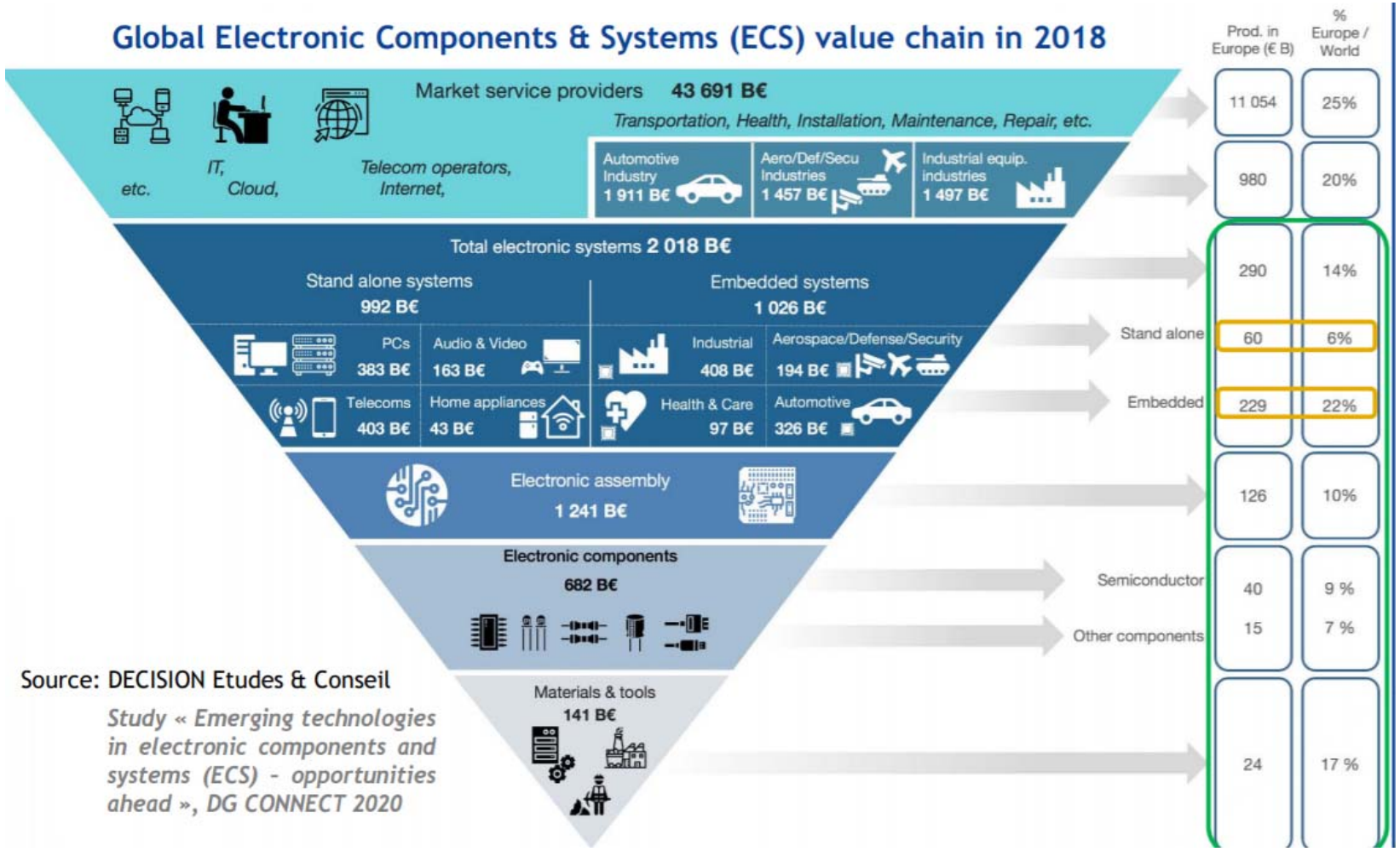


Solution:
Highly-parallel

In-Memory-Computing

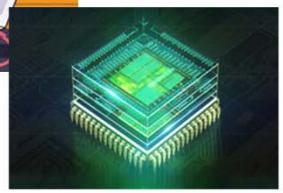
S. Barraud et al., 3D RRAMs with Gate-All-Around Stacked Nanosheet Transistors for In-Memory-Computing, IEEE IEDM 2020

From Materials to Services – toward integration ?



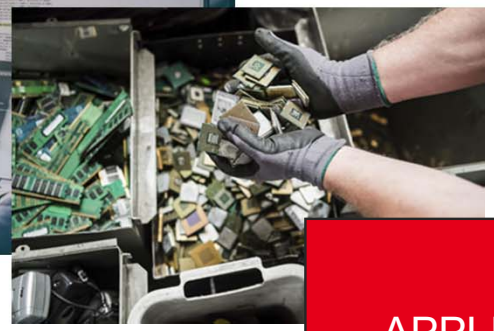
DESIGN/SYSTEM/APPLICATION – TECHNOLOGY CO-OPTIMIZATION

Research on
New technologies
Computing, telecom



IC architecture, manufacturing

System level optimization



End of life, recycling

Application/use
-level
optimization

Data lifecycle

DTCO

STCO

ATCO !

APPLICATION
& USE

Life Cycle
Analysis

ICT INDUSTRY:

60 elements are used, less than 15% is recycled

NEED for IoT
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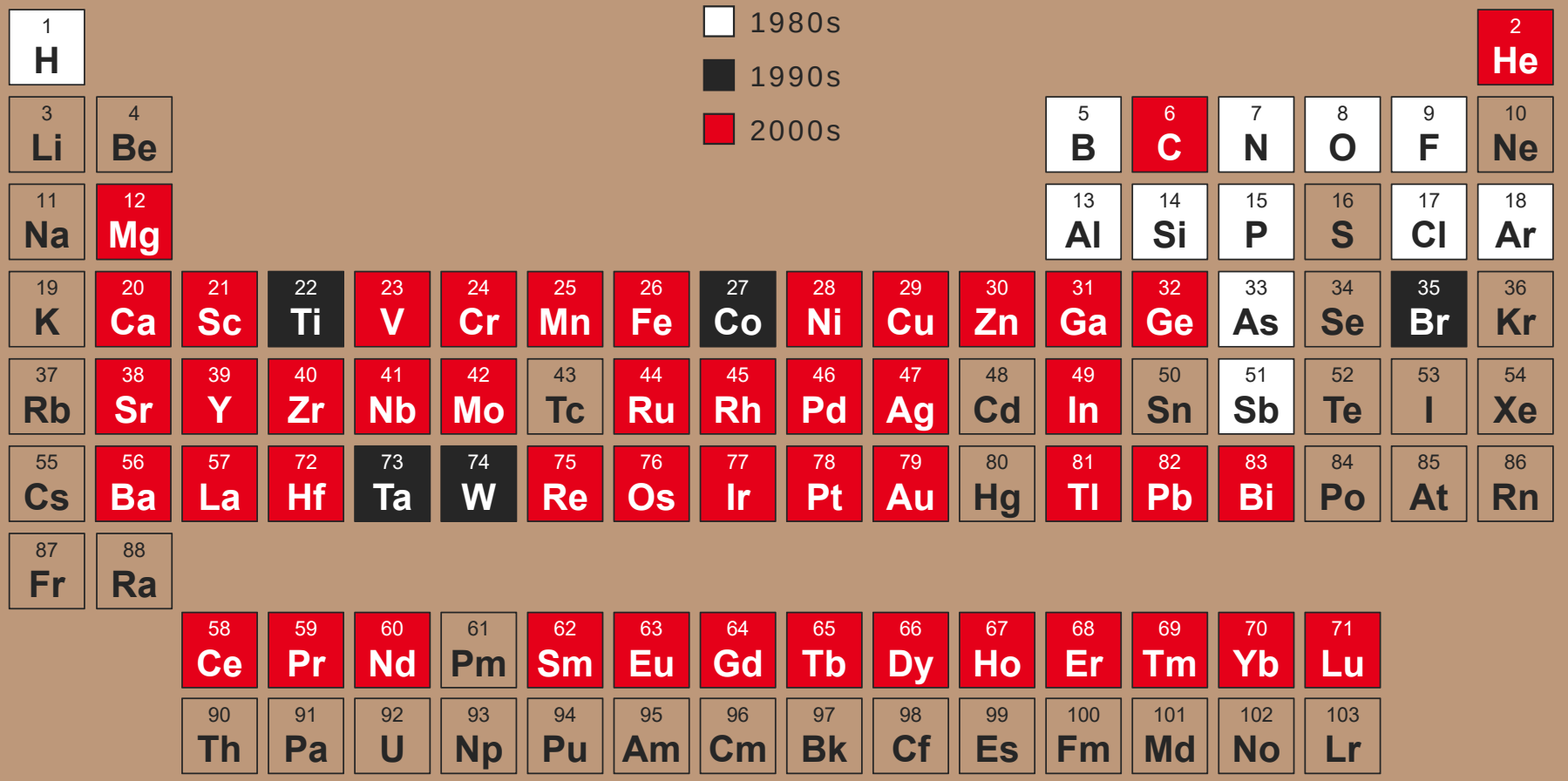

RARE EARTHS AND MINERALS

A small number of countries control the production

NEED for IoT
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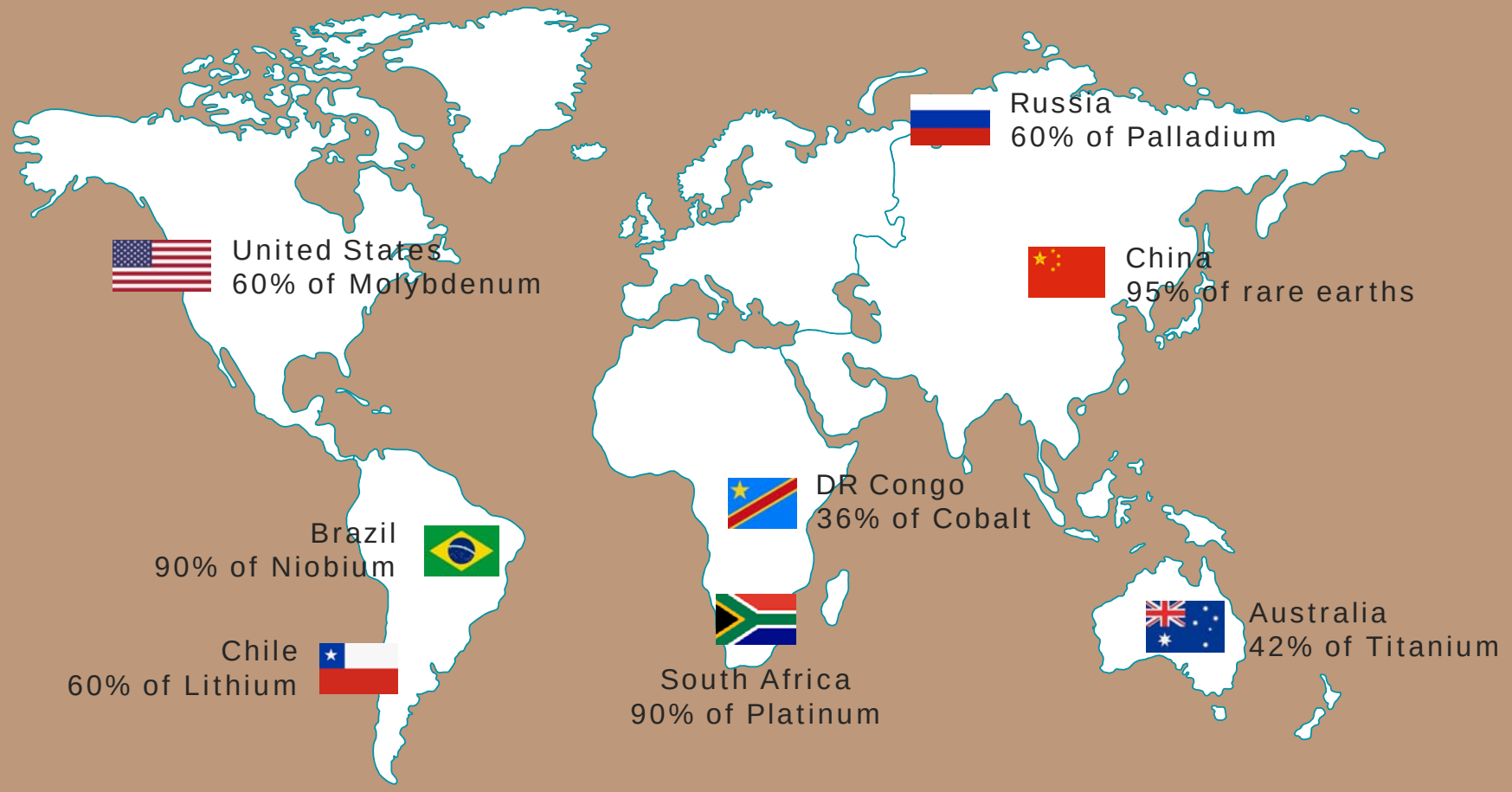
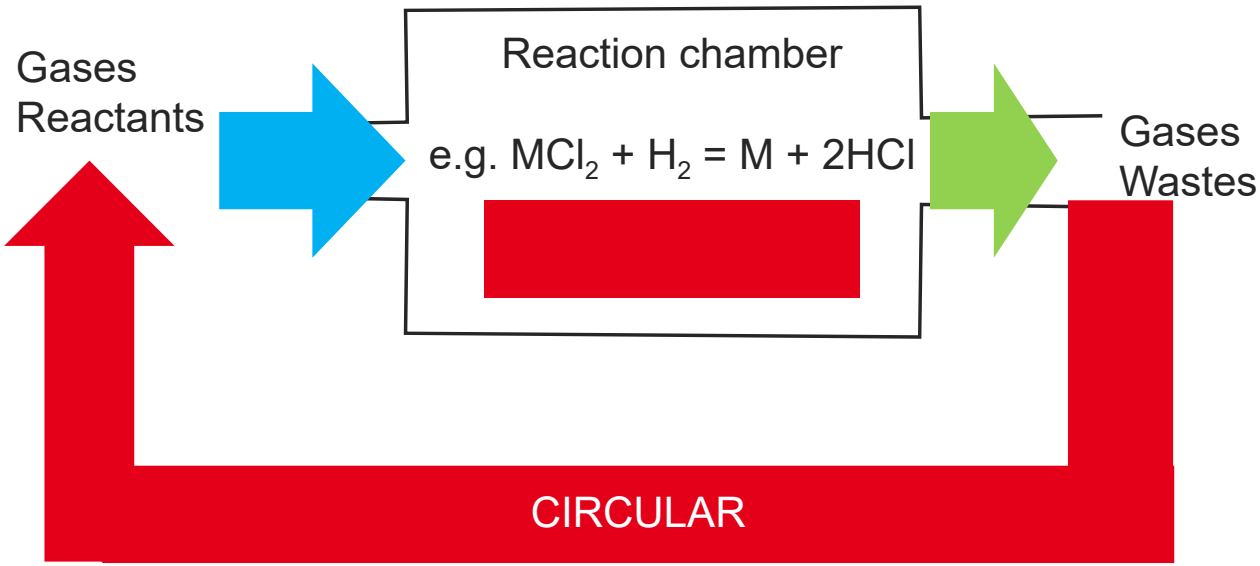
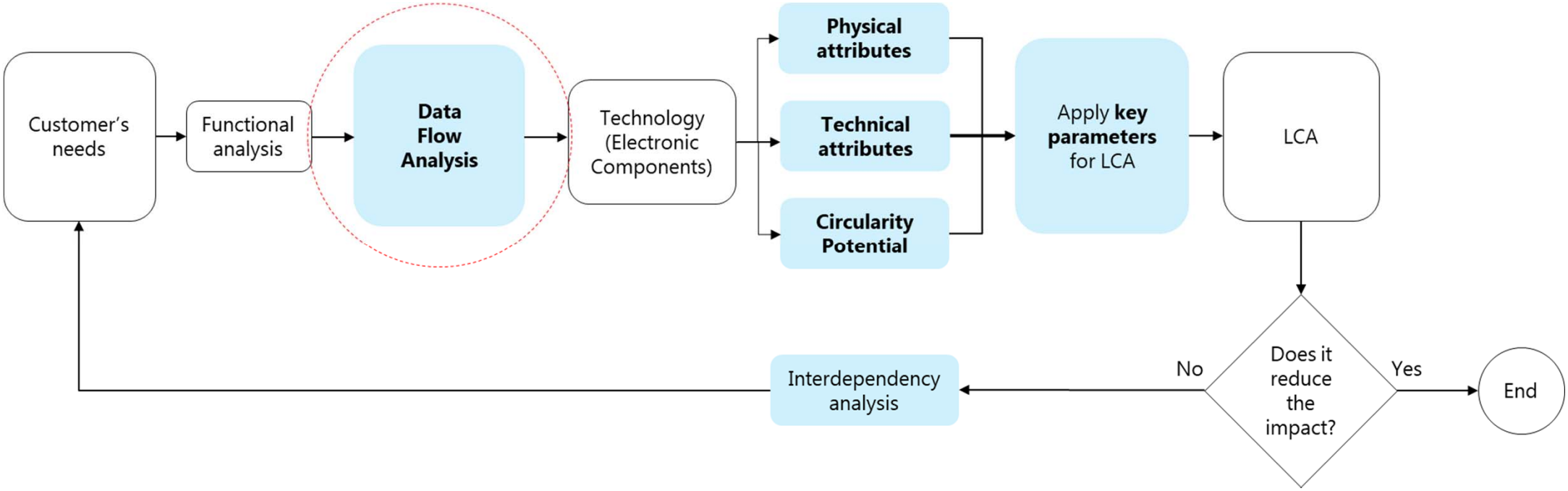


> 90% OF MATERIALS DEPOSITION BY CVD IS LOST !



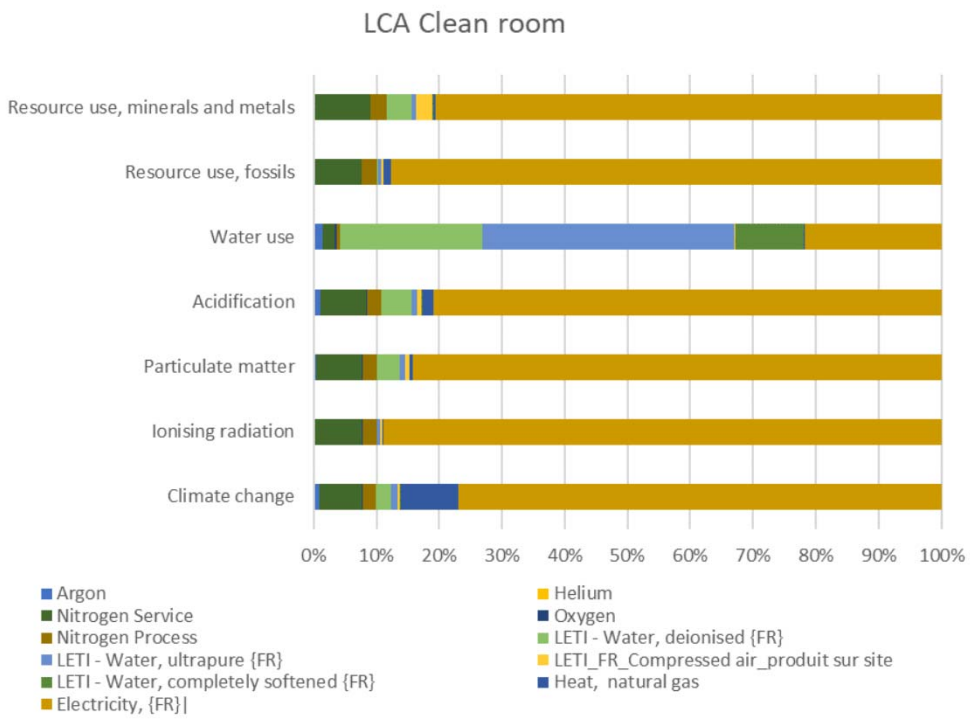
“ it is urgent to drastically reduce the consumption of minerals

IOT ECO DESIGN



E. Quisbert et al., a methodology for supporting the sustainable future and eco design of the Internet of Things, SUST 2021

SOME ACTIONS AT CEA-LETI IN 2022



See CEA-Leti 2022 Scientific Report ONLINE

1. LCA in 10+ research projects (ex: Power GaN, Microdisplay, Memories)

2. Lower energy consumption, more decarbonized energy, energy monitoring to boost equipment efficiency, and future ISO 50001 certification

3. PFC gas abatement and substitutes for hydrofluorocarbon (HFC) used in plasma etching to lower GWP (global warming potential)

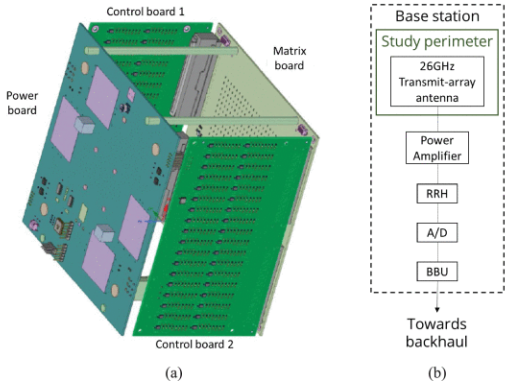
4. Reducing material usage (especially for critical materials), limiting waste during deposition, and recycling waste

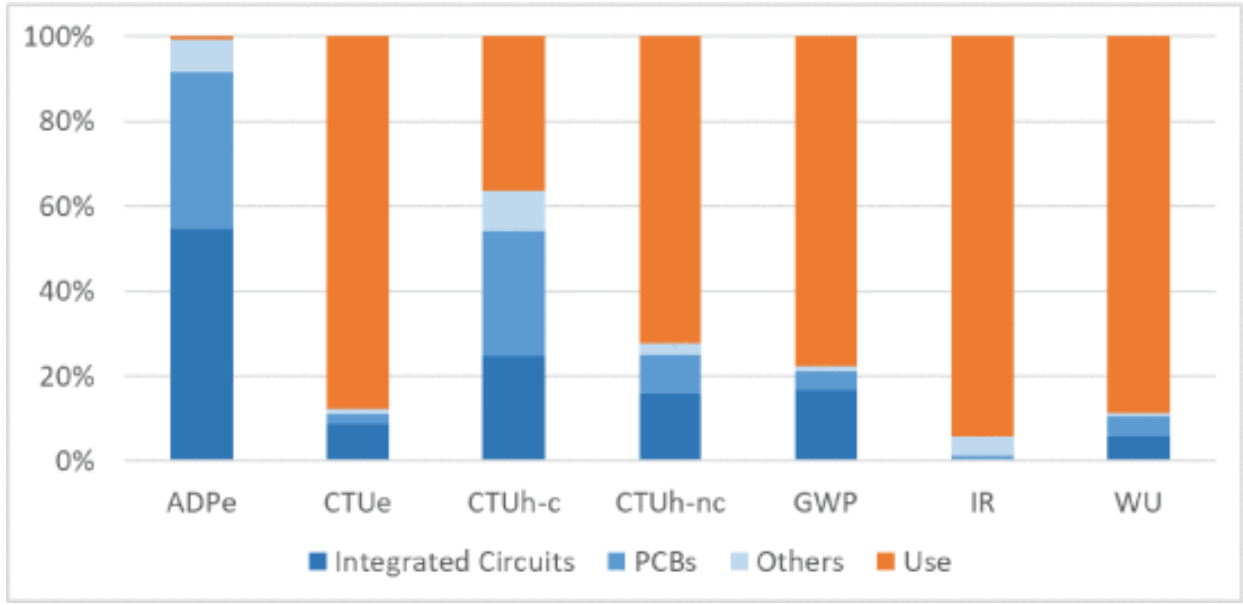
5. Choosing the most sustainable technologies among the available options :

TOWARD ECO-DESIGN OF A 5G MMWAVE TRANSMITARRAY ANTENNA BASED ON LIFE CYCLE ASSESSMENT

Acronym	Impact category	Unit	ILCD Level[a]
ADPe	Resource use, minerals and metals	kg SB eq.	III
CTUe	Ecotoxicity, freshwater	CTUe	III
CTUh-c	Human toxicity, cancer	CTUh	III
CTUh-nc	Human toxicity, non-cancer	CTUh	III
GWP	Climate change	kg CO2 eq.	I
IR	Ionising radiation, human health	kg U235 eq.	II
WU	Water use	m3 eq.	III

[a]ILCD level represents methods quality, there are classified as level I: recommended and satisfactory, level II: recommended but in need of some improvements, level III: recommended but to be applied with caution.





J. Guérid, L. Di Cioccio et al., 2022 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit),, doi: 10.1109/EuCNC/6GSummit54941.2022.9815659.

TOWARDS SUSTAINABLE ELECTRONICS

NEED for IoT
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Production
› reduction of waste and water
› recycling
› reduction of critical materials

IC design
› new computing paradigms
› stronger ultra low-power expertise

Eco-design of products
› extended lifetime
› life cycle analysis

Applications
› Dataflow lifecycle
› Sustainable global impact

Sober & high impact

End of life management
› recycling more materials from electronic waste

TO GO FURTHER

Digital	Biological
Exponentially growing complexity beyond what is needed (Standard Products)	Adaptive and progressive complexity (only what is required)
Separated from the natural environment	In perpetual interaction with its surroundings
Fully predetermined (PLC)	Reconfigurable, adaptable
Sometimes scarce and polluting mineral resources	Available organic or mineral resources
Energy-intensive manufacturing	Low energy birth and growth
Need for power supply	Transforms its own energy with the available resources of the environment
Very low energy for an elementary calculation	Low energy for a complex system

BUSINESS MODELS WILL CHANGE !

NEED for IoT
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- ✓ OBJECT ECONOMY TO SERVICES
- ✓ HIGH TECH TO RIGH TECH
- ✓ MINING AND WASTE TO CIRCULAR
- ✓ INOVATION TO ECO-INOVATION

SOME REFERENCES

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2 The environmental footprint of the digital world 2019 GreenIT.fr, F Bordage.
3 J. Lopes Barbosa et al. “environnemental impacts of a clean room infrastructure.” Journal of cleaner production (2023) To be published.
4 I. Servin, et al., J. Micro and Nano Engineering (2022) submitted.
5 A. Holo, et al. « MicroLED Display Life Cycle Assessment » to be presented at Display week (2023).
6 J. Guérid, J. -B. Doré, J. Reverdy, B. Reig, A. Clemente and L. Di Cioccio, "Toward Eco-Design of a 5G mmWave Transmitarray Antenna Based on Life Cycle Assessment," 2022 Joint European Conference on Networks and Communications & 6G Summit (EuCNC/6G Summit), Grenoble, France, 2022, pp. 440-445, doi: 10.1109/EuCNC/6GSummit54941.2022.9815659.
7 Y Rivoira , et al. « Environmental Impact Comparison Between OxRAM And MRAM Component Based On Life Cycle Assessment» To be submitted to Journal of Cleaner Production 2023.
8 G. Guillemaud, L.Vauche, et al. “ Empreinte environnementale d’un composant de puissance à base de GaN”submitted to GIE 2023
6 T. Ernst « Vers une électronique soutenable dans un monde digital Enjeux et perspectives, Revue d’Electronique et d’Electricité » n°5, 2023.
7 T. Ernst & JP Raskin “ Towards circular ICT: from materials to components”, Hipeac vision 2023, https://www.hipeac.net/

Thank you

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