Vers une électronique soutenable

Enjeux et Perspectives

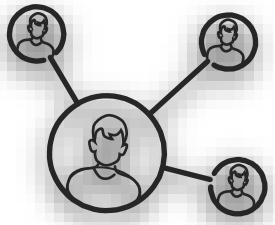
T Ernst

Séminaire Aristote, Ecole Polytechnique,
13/04/2023

DATA DRIVEN AREA
EVOLUTION WITHIN 10 YEARS 2010 - 2020

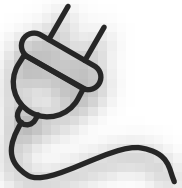
World population

+11%



Internet users

+135%

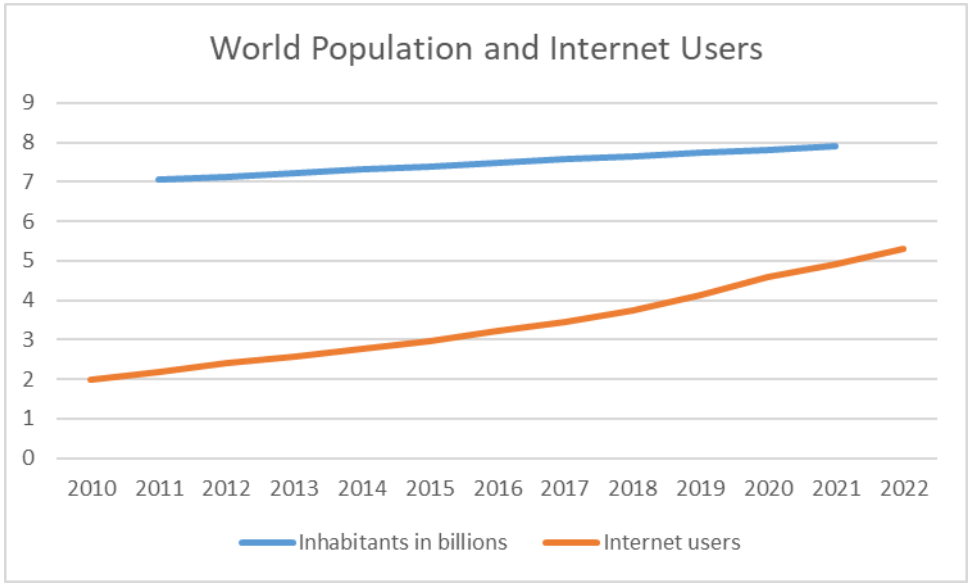


Electricity

+28%

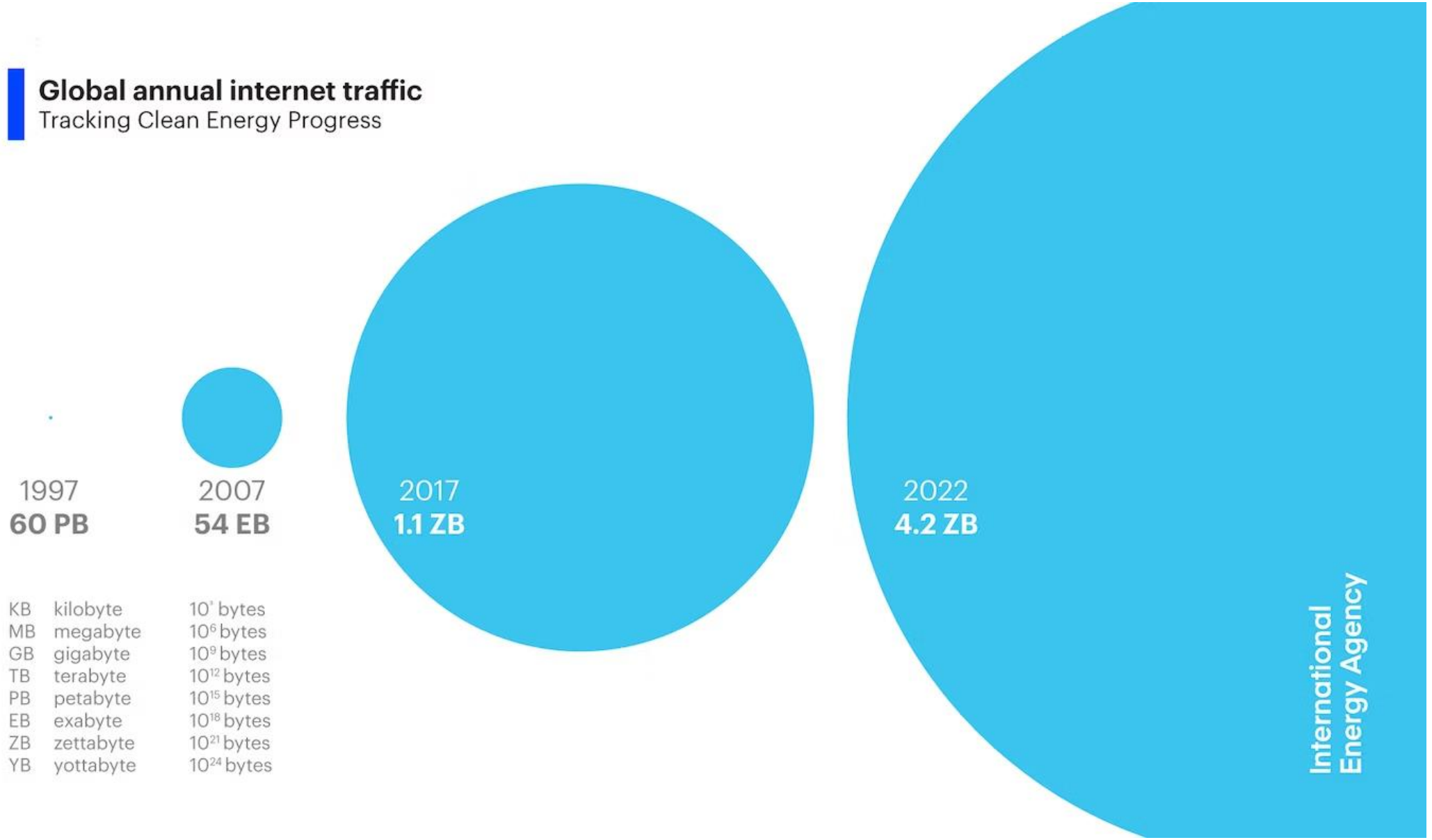
X14 Mobile users in Africa

(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
Groupe d'expertise et de conseil intergouvernemental sur l'évolution du climat

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

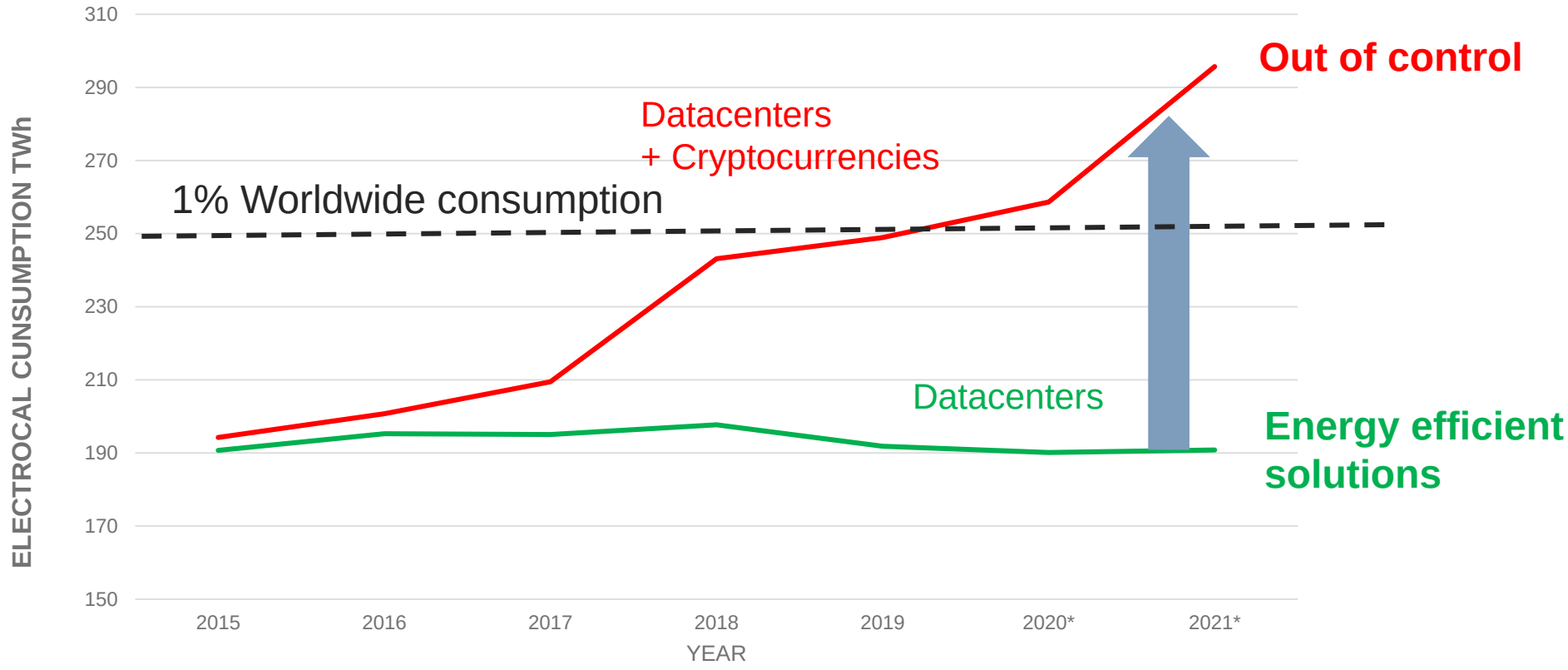
Next 35 years will need more than all our history

Source: www.systext.org

3. GEOSTRATEGIC DEPENDENCIES

China controls most refining of Co, Ni, Li and

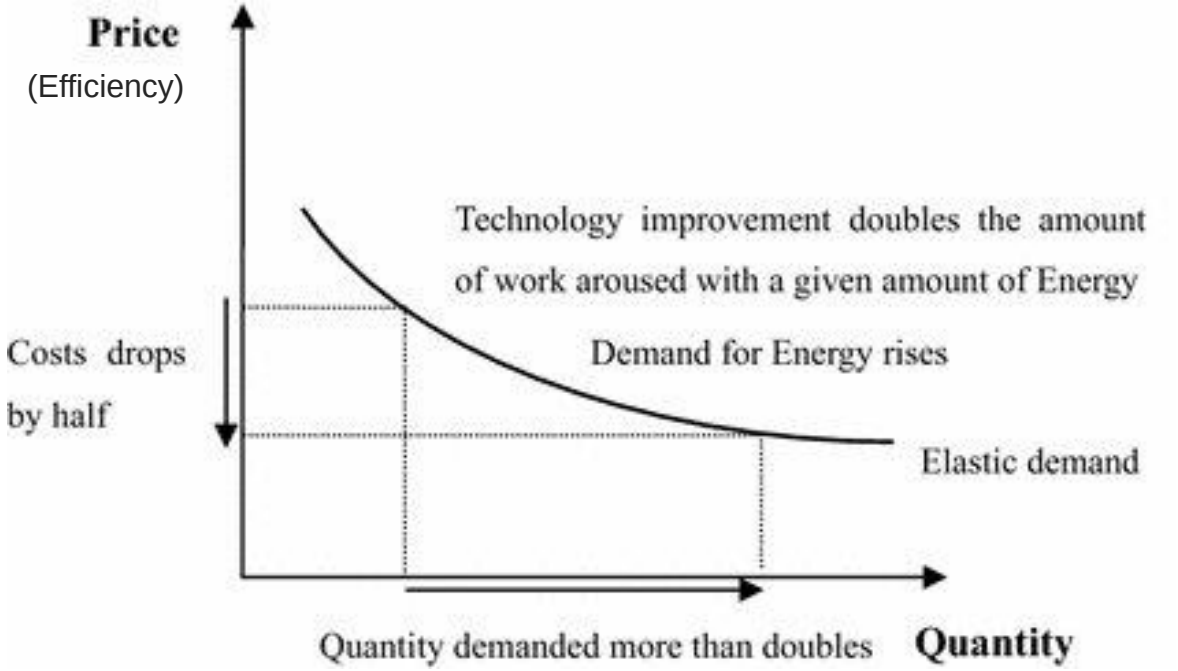
Datacenters vs Cryptocurrencies electrical consumption (Use only !)



Worldwide energy consumption in 2021: 25 000 TWh

JEVONS PARADOX (REBOUND EFFECT)

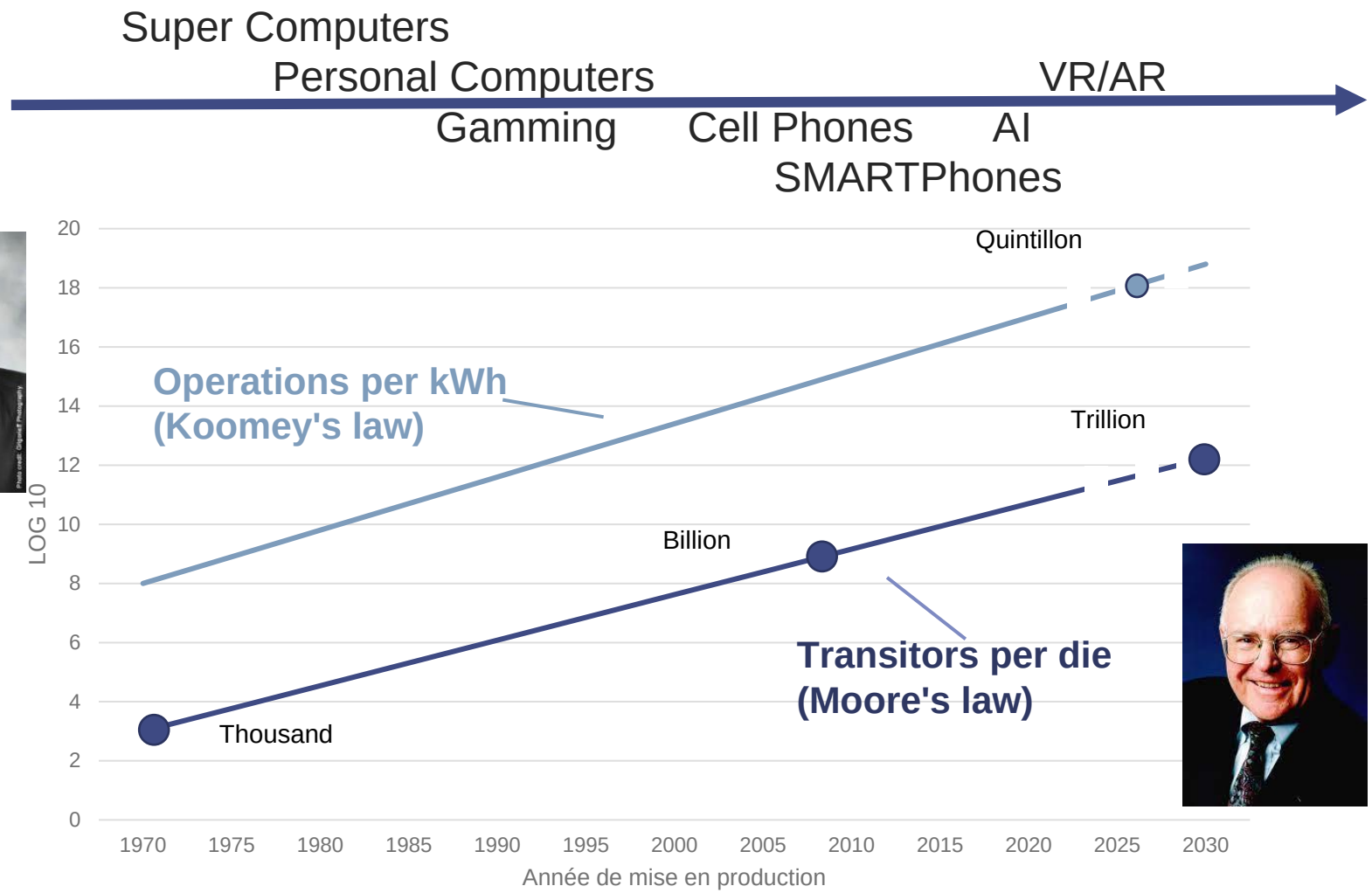
W. S. Jevons



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

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

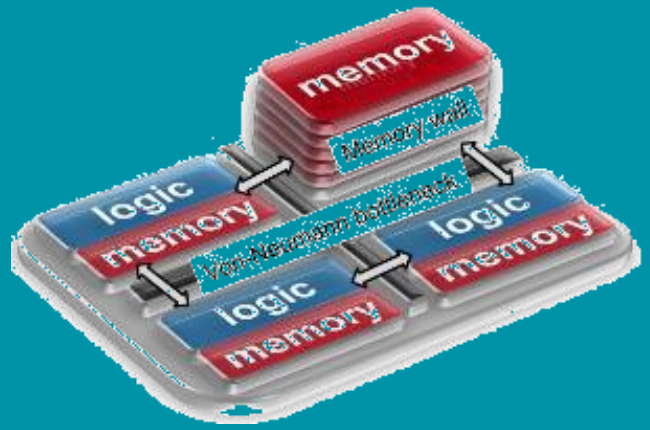
SCALING- ENERGY EFFICIENCY AND APPLICATIONS



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

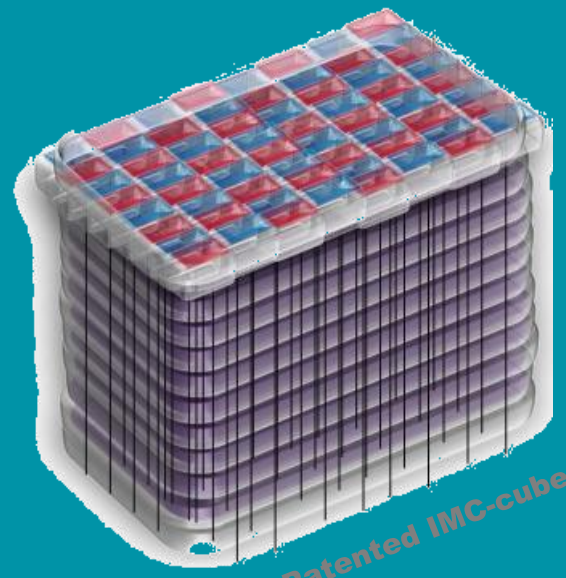
ENERGY EFFICIENCY – LESS DATA MOVES TOWARDS THE ULTIMATE IN-MEMORY-COMPUTING

Today



Problem:
Energy-efficiency in data-abundant integrated circuits

Tomorrow



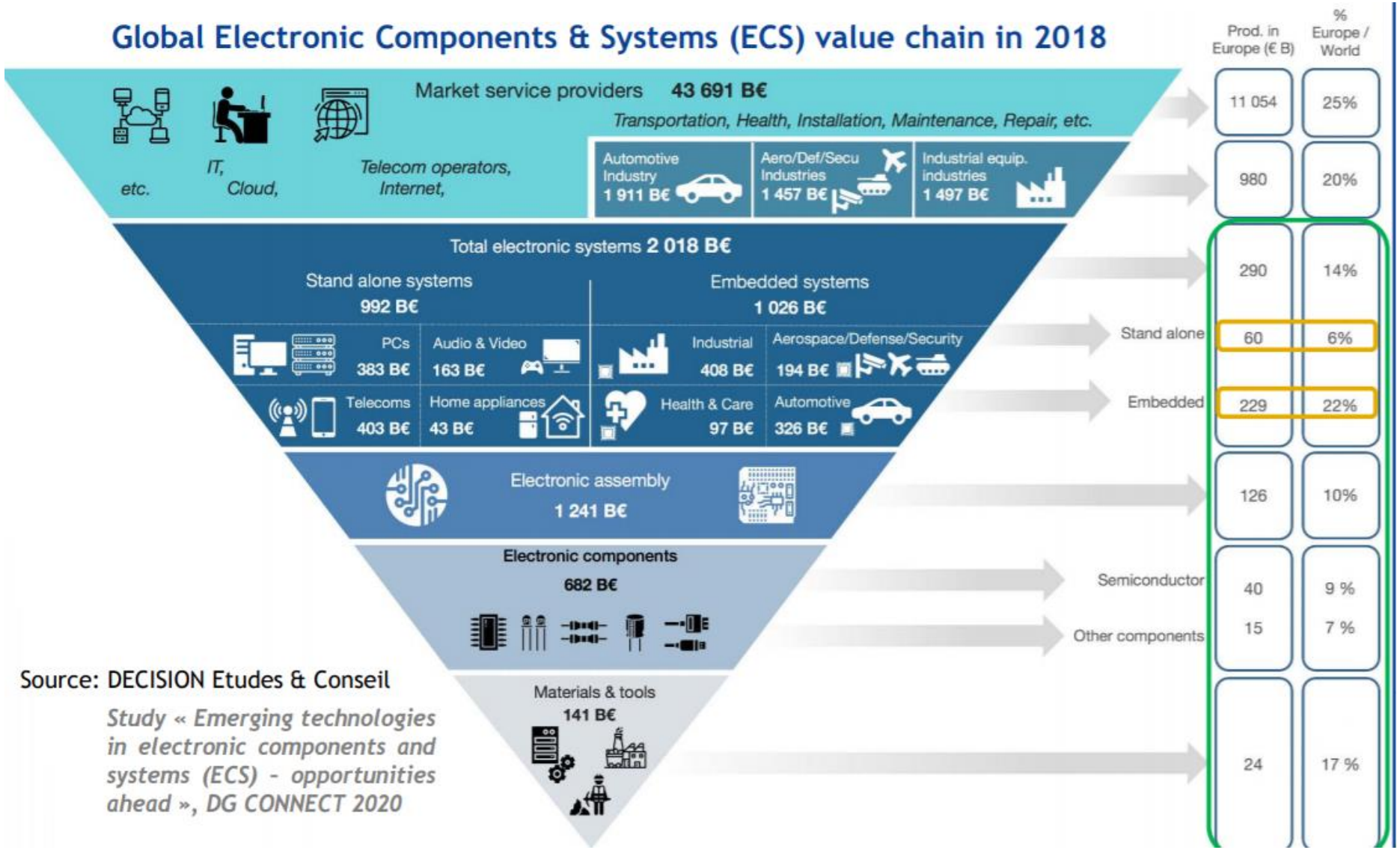
erc

- vertical memories
- 3D stacks
- vertically stacked nanowires
- circuit demonstrators
- software tools

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 ?



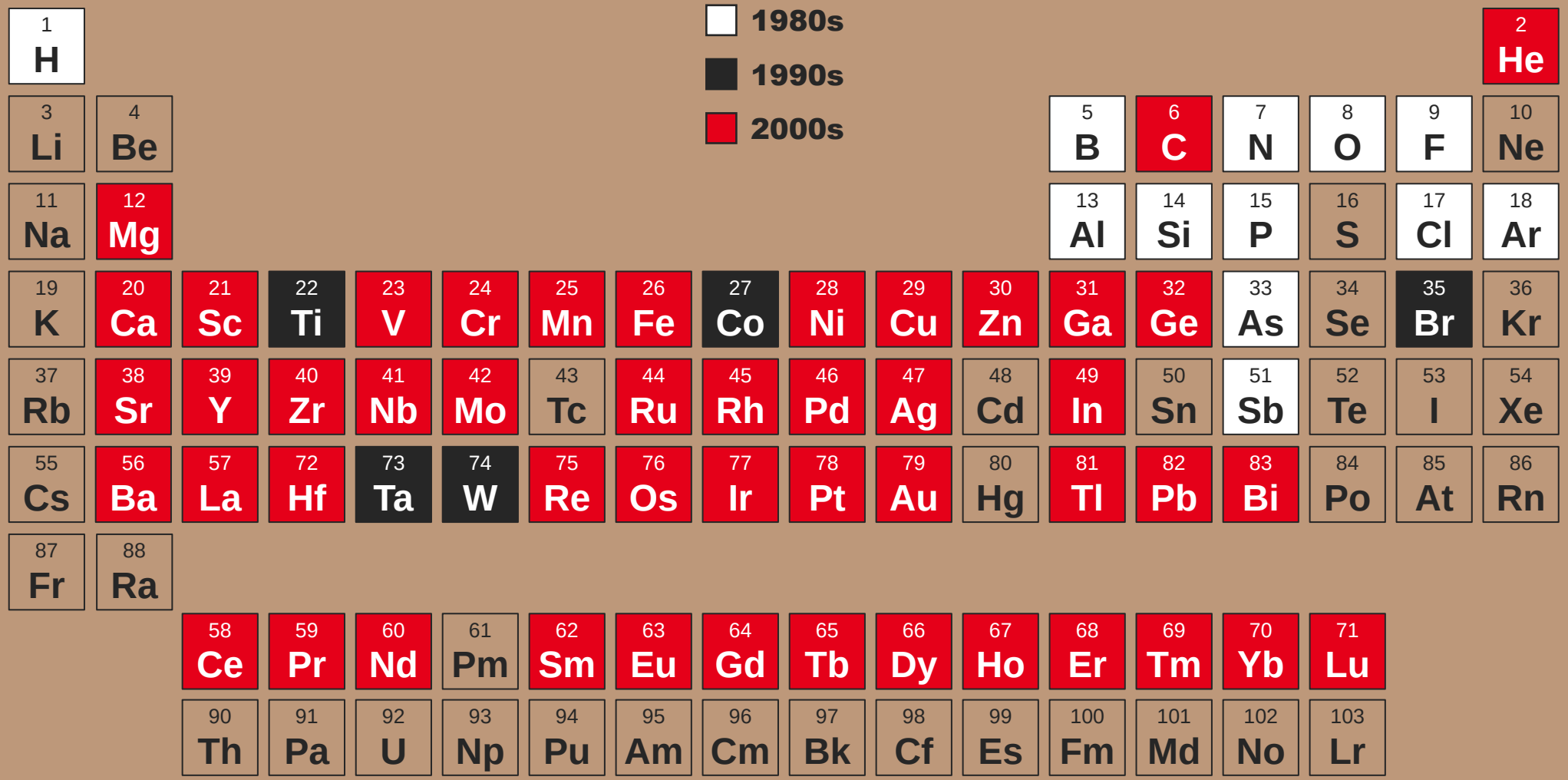
Source: DECISION Etudes & Conseil

Study « Emerging technologies in electronic components and systems (ECS) - opportunities ahead », DG CONNECT 2020

ICT INDUSTRY:

60 elements are used, less than 15% is recycled

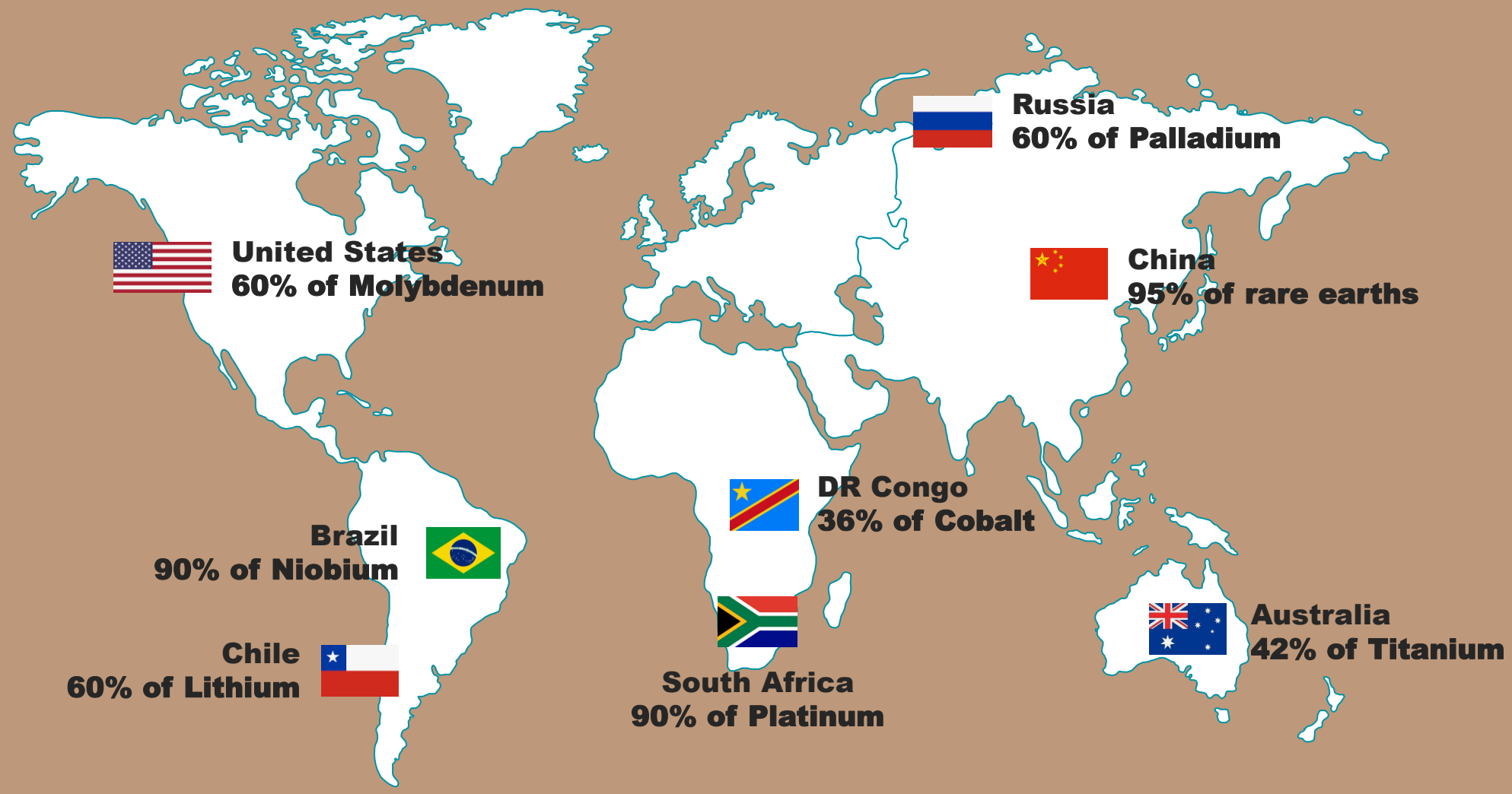
NEED for IoT
Université Grenoble Alpes



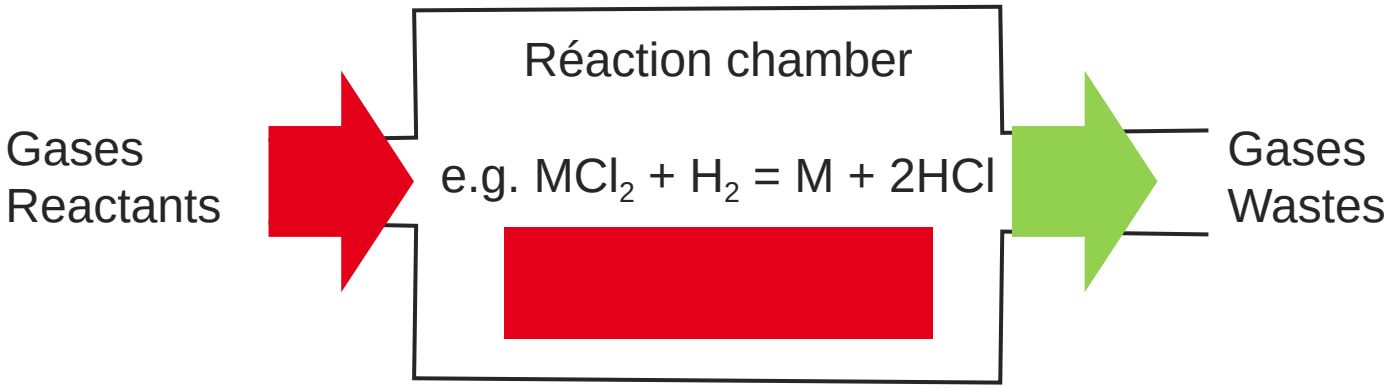
RARE EARTHS AND MINERALS

A small number of countries control the production

NEED for IoT
Université Grenoble Alpes



> 90% OF MATERIALS DEPOSITION BY CVD IS LOST !



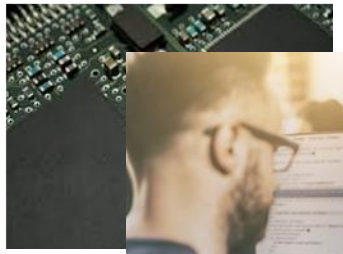
“it is urgent to drastically reduce the consumption of minerals

DESIGN/SYSTEM/APPLICATION – TECHNOLOGY CO-OPTIMIZATION

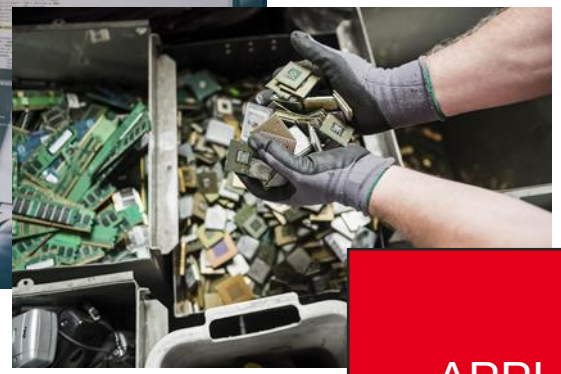
Research on
New technologies
Computing, telecom

IC architecture, manufacturing

System level optimization



End of life, recycling



Application/use
-level
optimization

Data lifecycle

DTCO

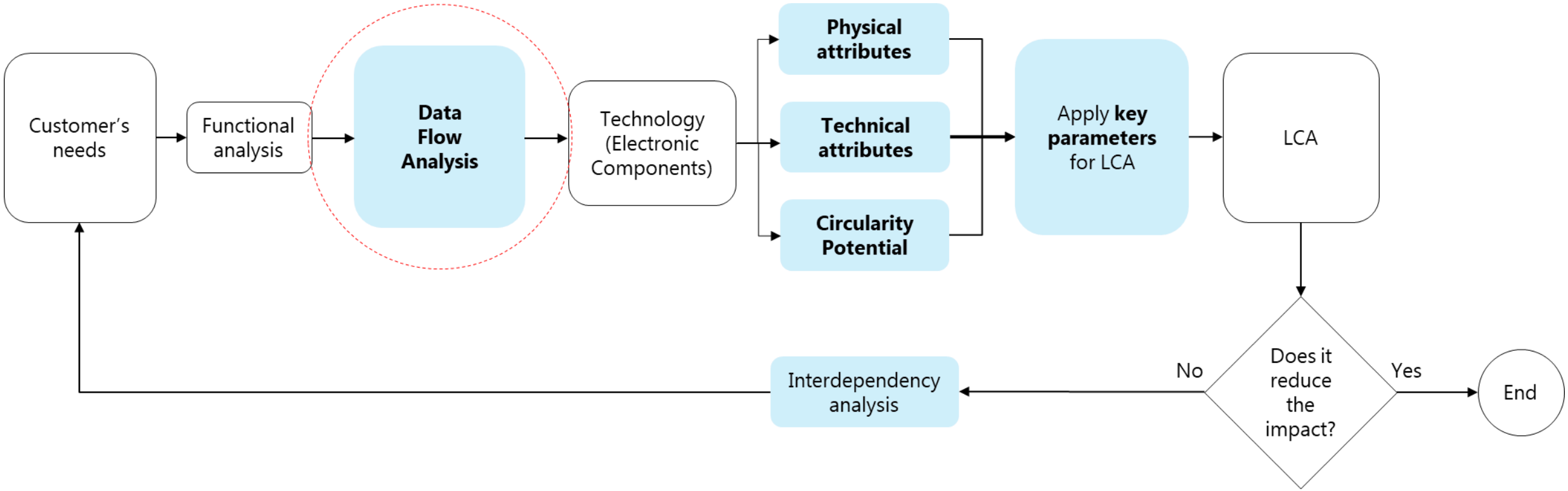
STCO

ATCO !

Life Cycle
Analysis

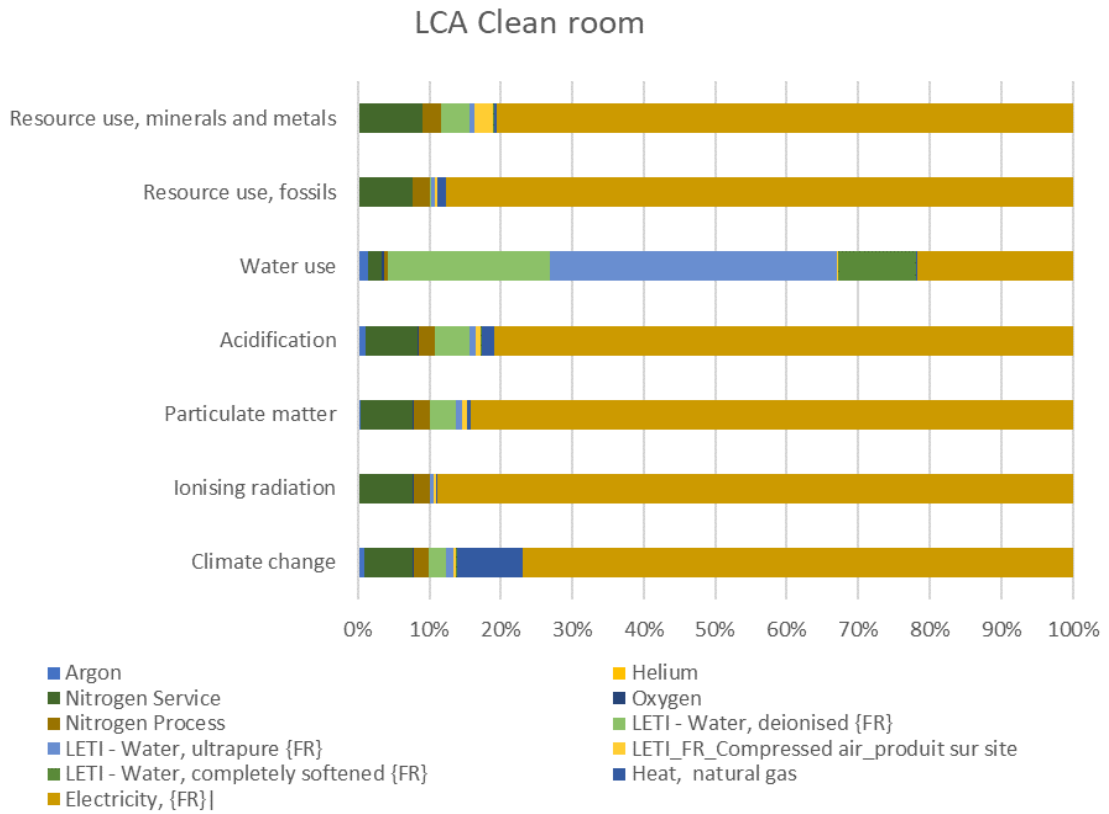
APPLICATION
& USE

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

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 (3-7)

TOWARDS SUSTAINABLE ELECTRONICS

NEED for IoT
Université Grenoble Alpes

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

POUR ALLER PLUS LOIN

Numérique	Biologique
Complexité à croissance exponentielle au-delà du nécessaire (Produits standards)	Complexité adaptative et progressive (seulement ce qui est nécessaire)
Séparé de l’environnement naturel	En perpétuel interaction avec son environnent
Totalement prédéterminé (automate)	Reconfigurable, adaptable
Ressources minérales parfois rares et polluantes	Ressources organiques ou minérales disponibles
Fabrication énergivore	Naissance et croissance peu énergivore
Besoin d’une alimentation en énergie	Transforme sa propre énergie avec les ressources disponibles de l’environnement
Energie très faible pour un calcul élémentaire	Energie faible pour un système complexe

BUSINESS MODELS WILL CHANGE !

NEED for IoT
Université Grenoble Alpes

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

SOME REFERENCES

1 IEA Global Energy Review 2021, SEMI.
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/

Merci de votre attention

CONTACT ECO-DESIGN @ CEA-LETI

Lea Di Cioccio

CEA-Leti, Grenoble, France

cea-leti.com

thomas.ernst@cea.fr