GREENER ECS
JOINING FORCES IN EUROPE

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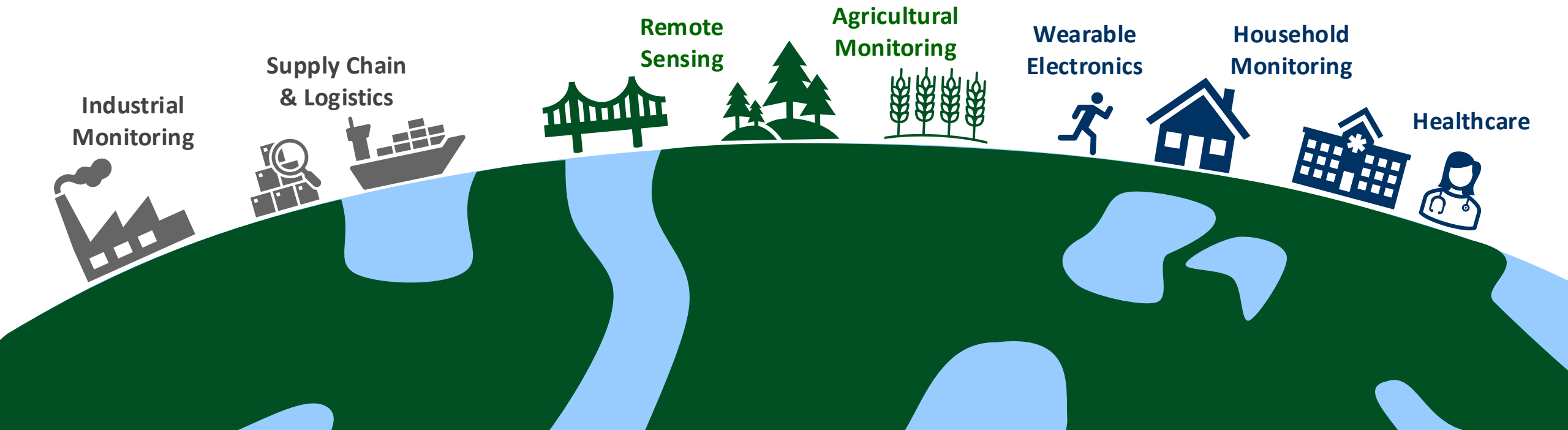
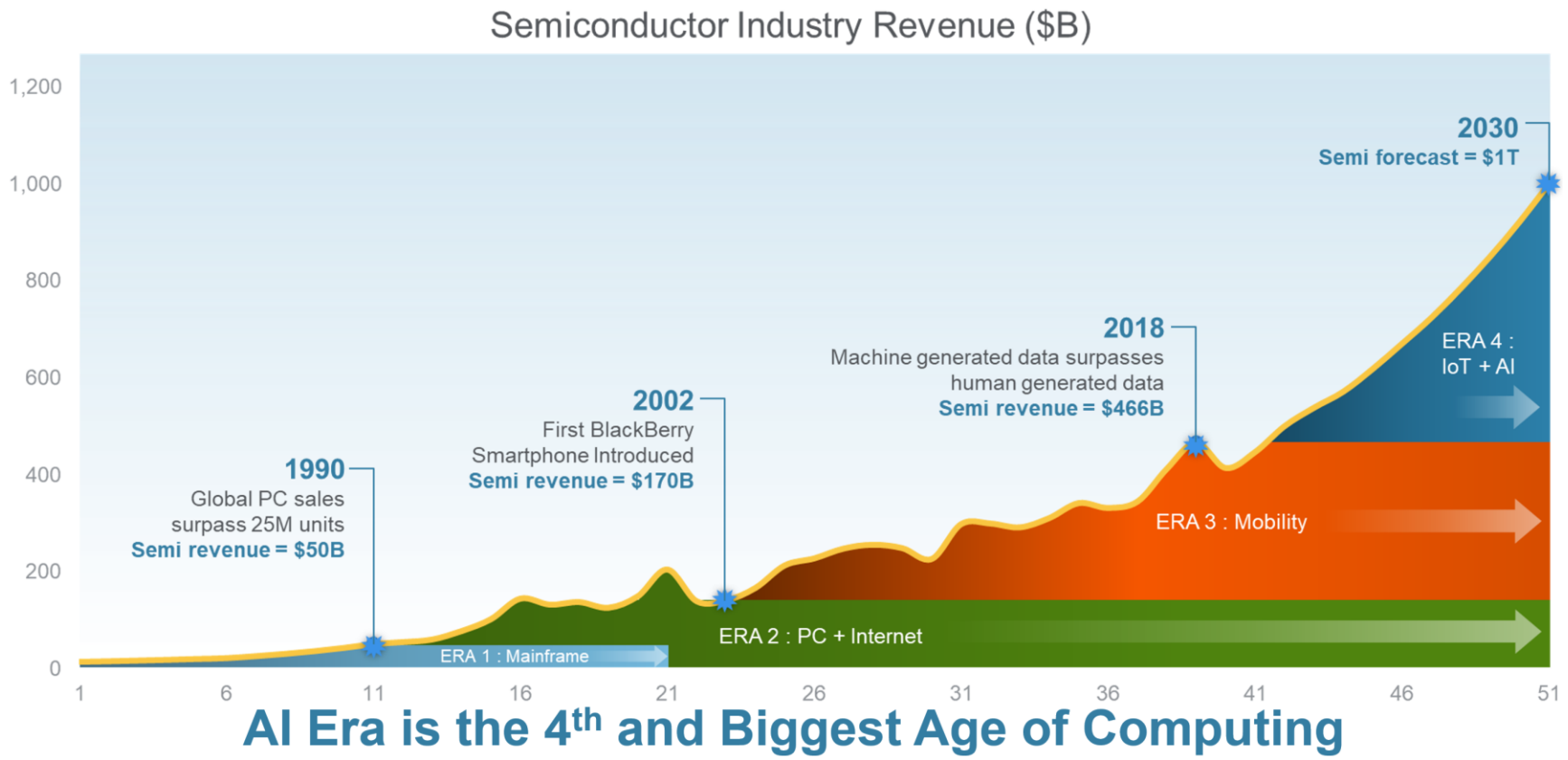
05.12.2024

INCREASED USE OF ELECTRICAL COMPONENTS AND SYSTEMS (ECS)

- Increasing production volumes
- Frequently have short lifetimes
- Minimally recycled



BY 2030, THE WORLDWIDE SEMICONDUCTORS (SC) INDUSTRY MANUFACTURING CAPACITY SHOULD NEARLY DOUBLE AS OF TODAY



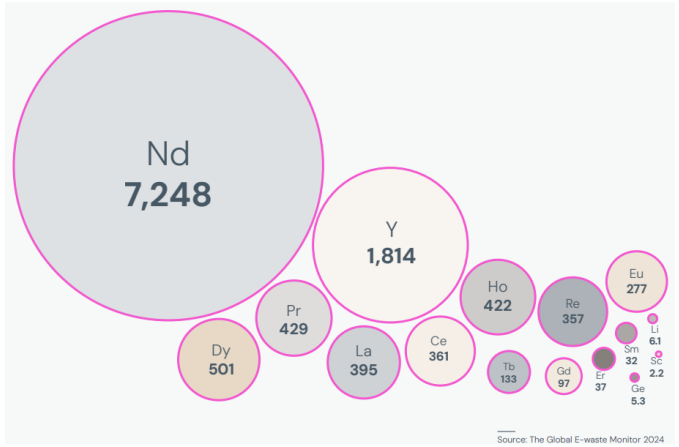
Source: SIA, Applied Materials - SMI

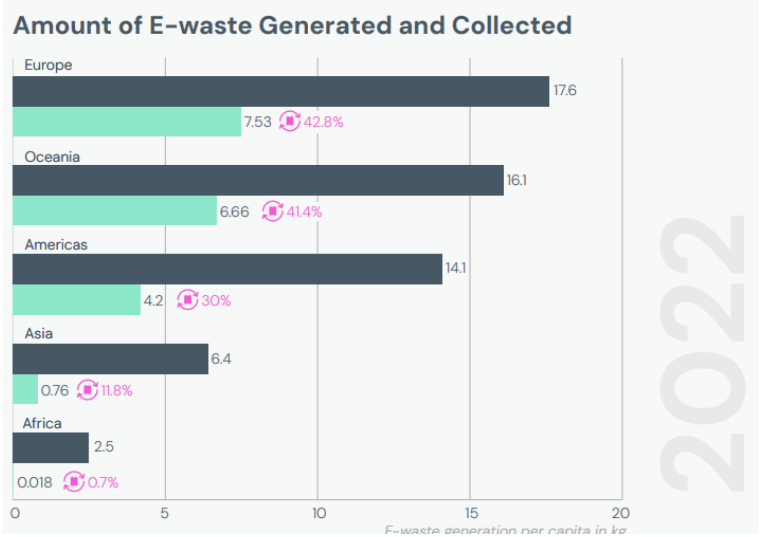
EU Semicon capacity increase by factor of 4-5!

Emissions & waste & energy need increase accordingly!

TWO PROBLEMS: EMISSIONS AND E-WASTE

Unsustainable Materials + Unsustainable Practices = Cause for Concern





Global E-waste production:

≈ 62 Mt

Global E-waste recycling rate:

≈ 22.3%

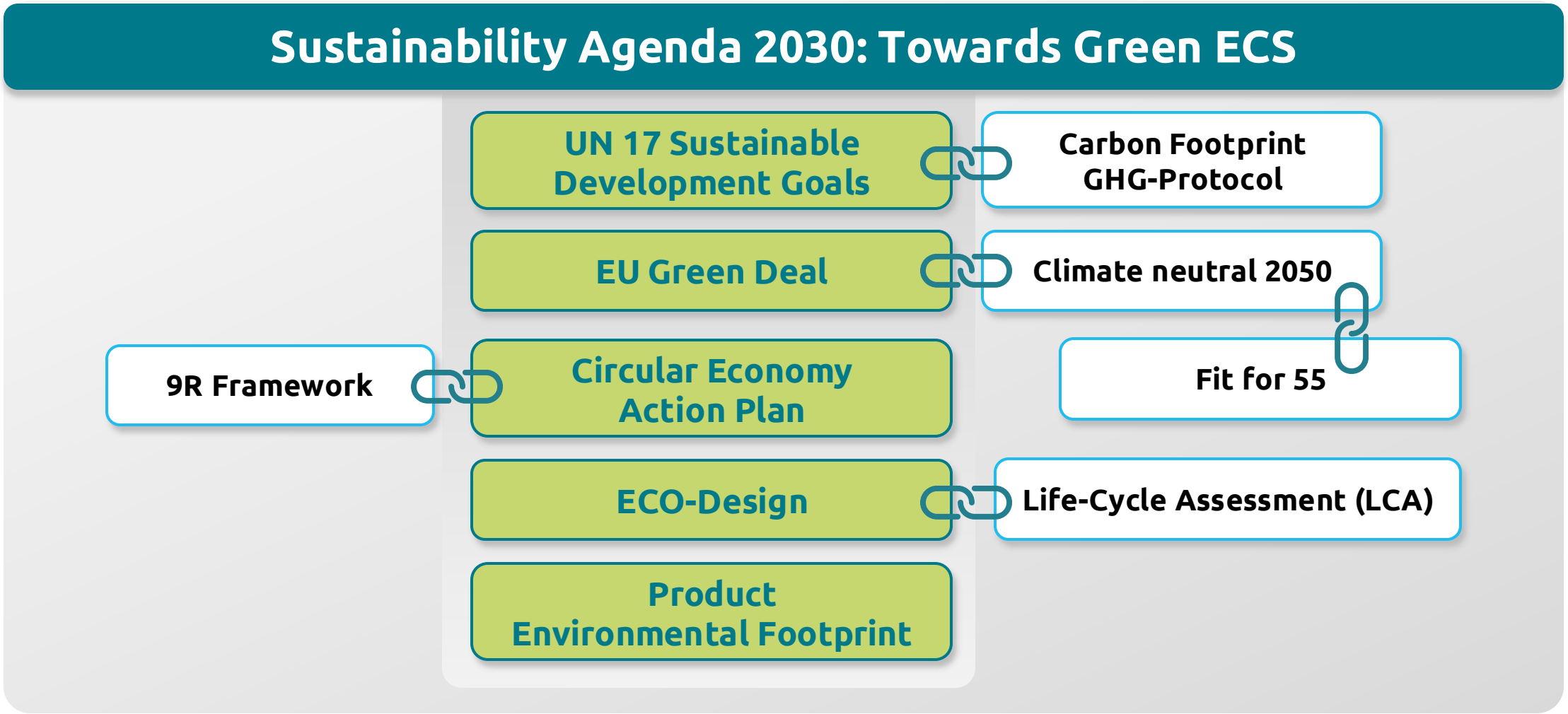
Global semiconductor lifetime CO_2 footprint

≈ 500 Mt

E-waste values based on 2021 estimates as reported in the Global E-Waste Monitor 2024.
In 2021 manufactured semiconductor devices lifetime CO2 [illegible] in BOM [illegible]

THE EUROPEAN CLIMATE LAW SETS AMBITIOUS GOALS:

A 55% REDUCTION IN GREENHOUSE GAS EMISSIONS BY 2030 AND CLIMATE NEUTRALITY BY 2050

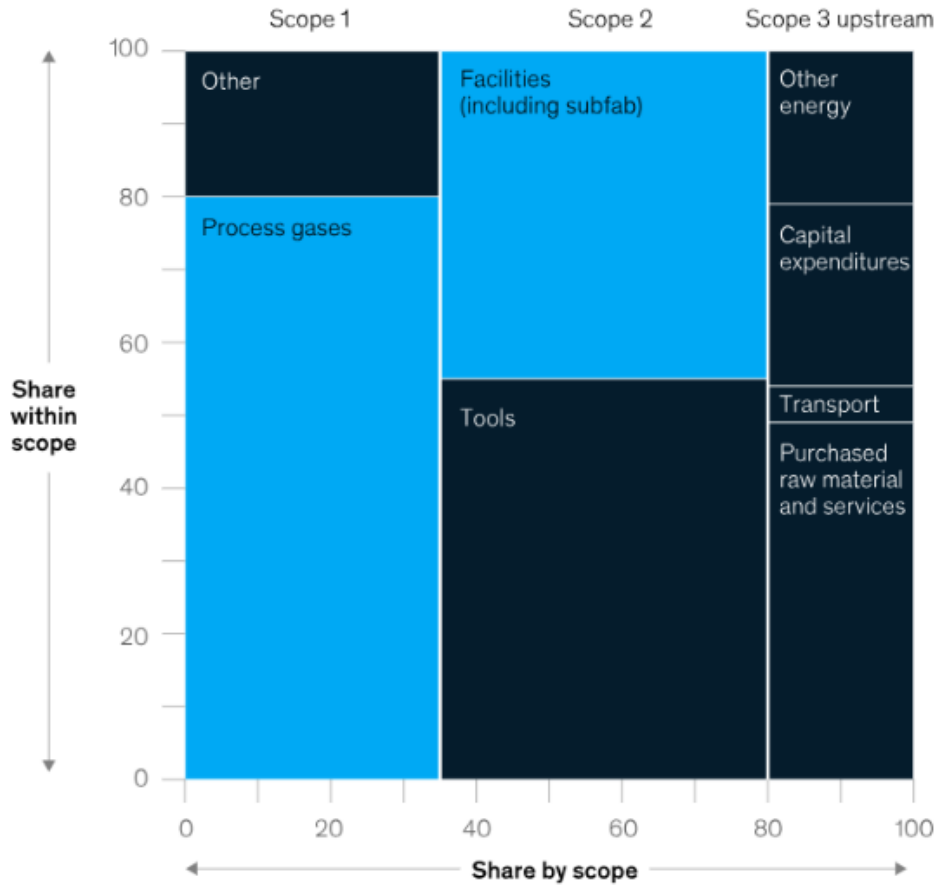


EPoSS: ECS Sustainability & Environmental Footprint (https://zenodo.org/records/11487615)

SEMICONDUCTOR FAB EMISSIONS

COME MAINLY FROM PROCESS GASES AND ELECTRICITY CONSUMPTION

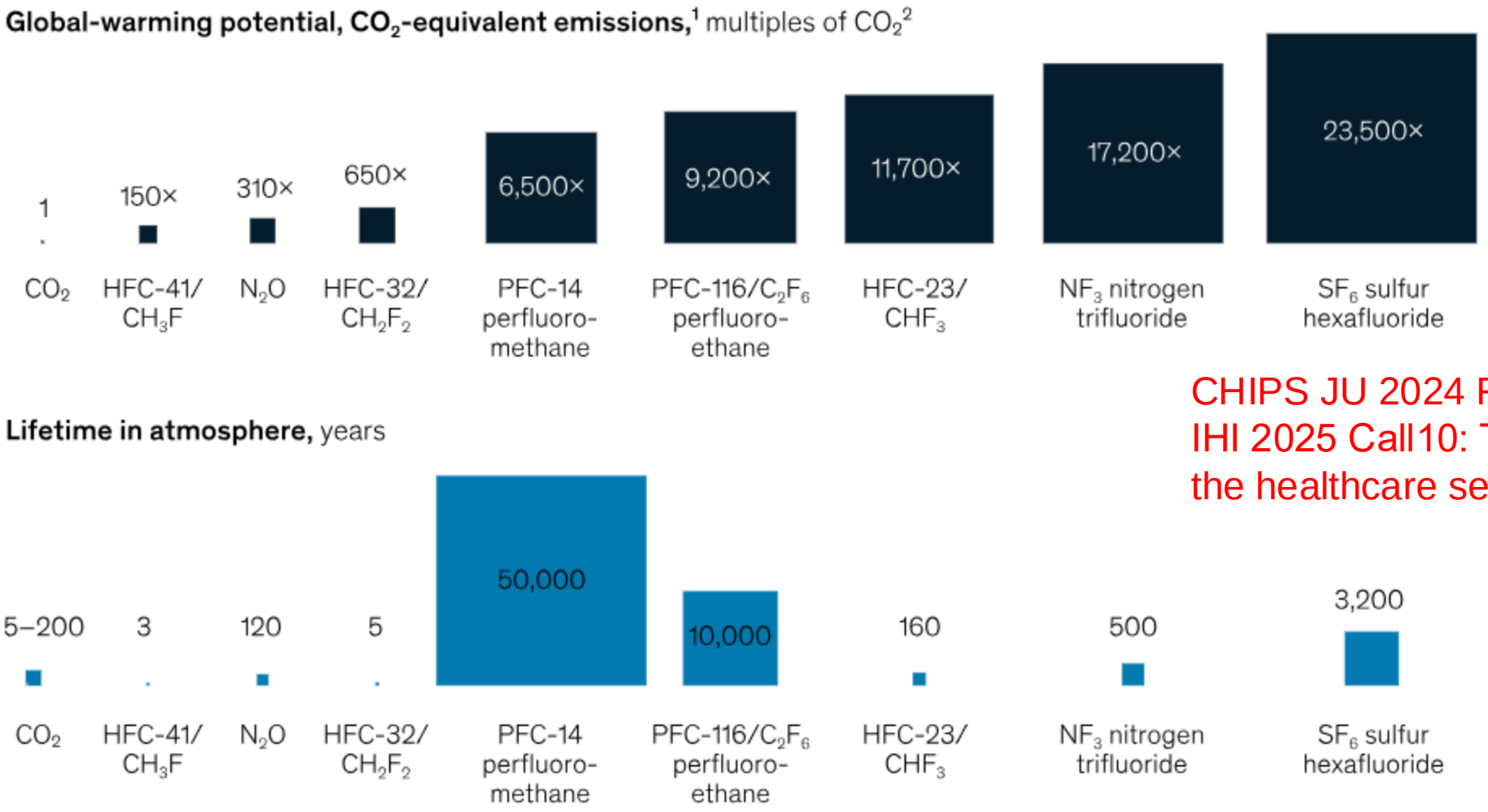
CO_2-equivalent emissions for typical fab profile,[1] % share



[1]Excluding scope 3 downstream. Emissions averaged across 200-millimeter (mm) and 300-mm semiconductor fabs.

McKinsey & Company

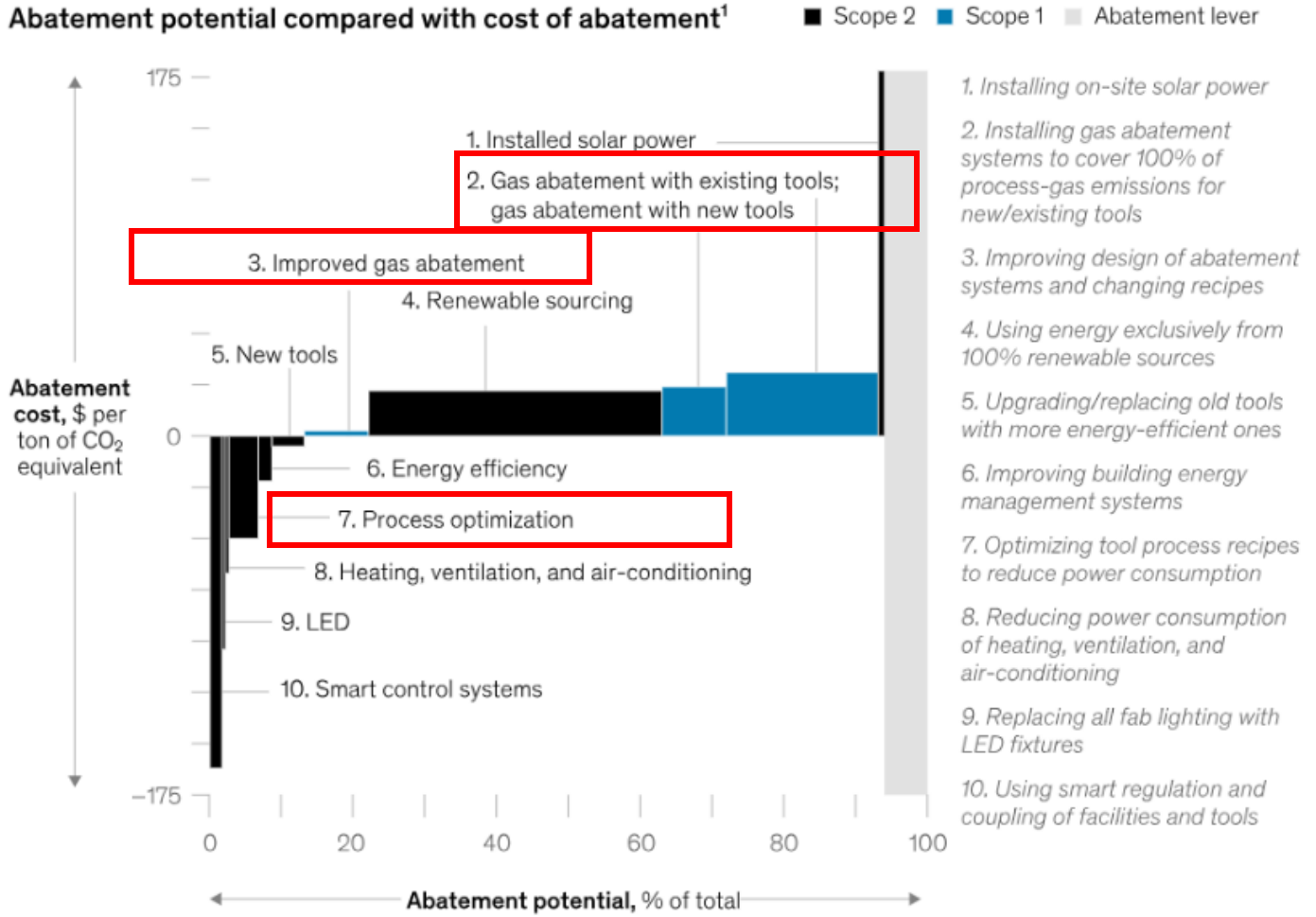
ENVIRONMENTAL IMPACT OF KEY PROCESS GASES



CHIPS JU 2024 Focus Topic (PFAS)
IHI 2025 Call10: Topic 3: PFAS …in the healthcare sector

REDUCTION OF GREENHOUSE GASES VS IMPLEMENTATION COSTS

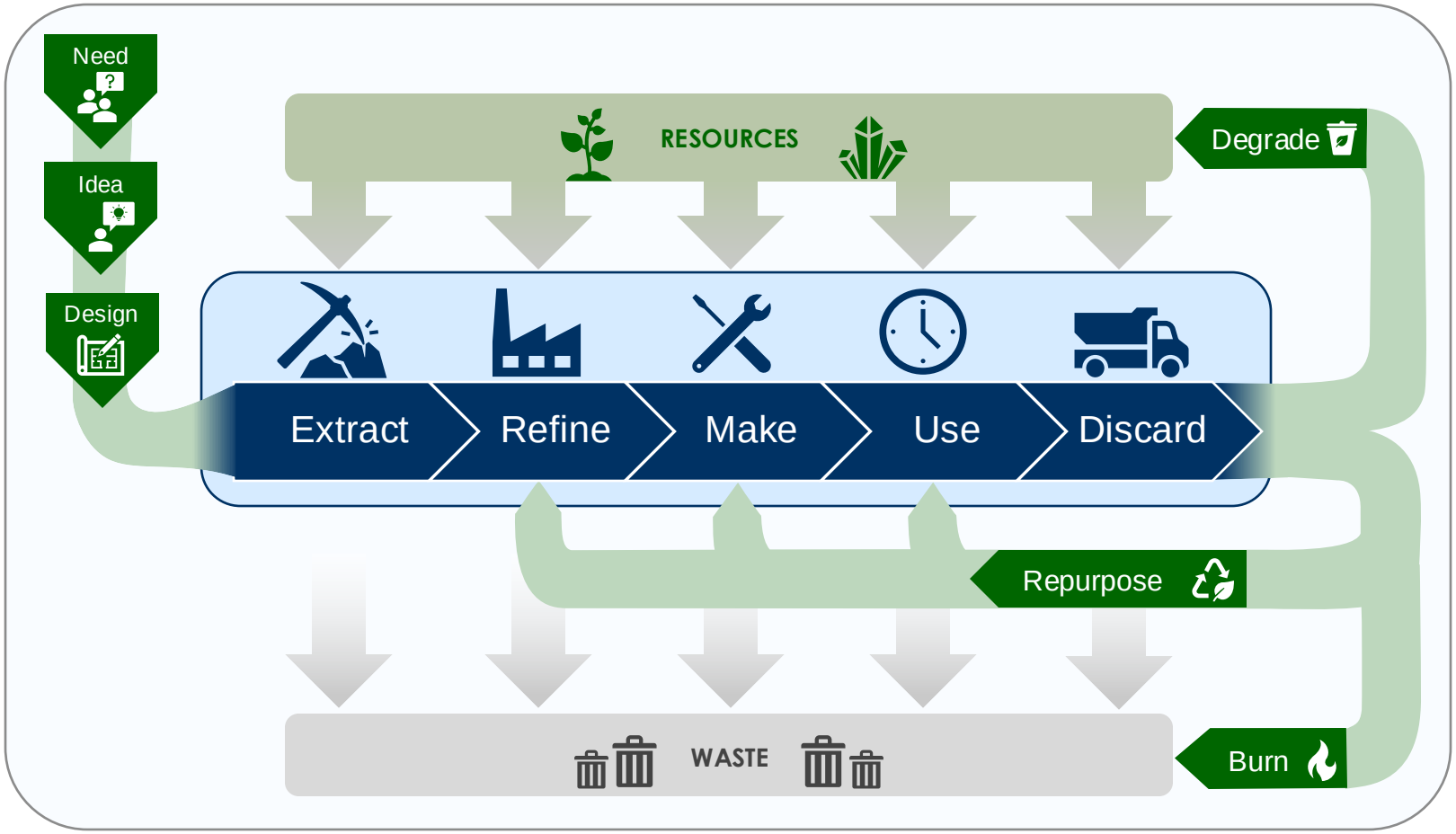
CHIPS JU 2024 Focus Topic

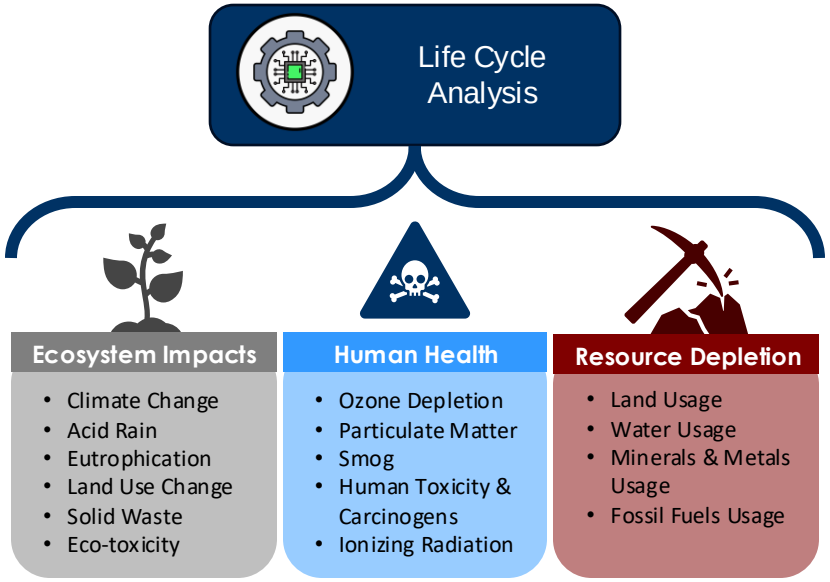


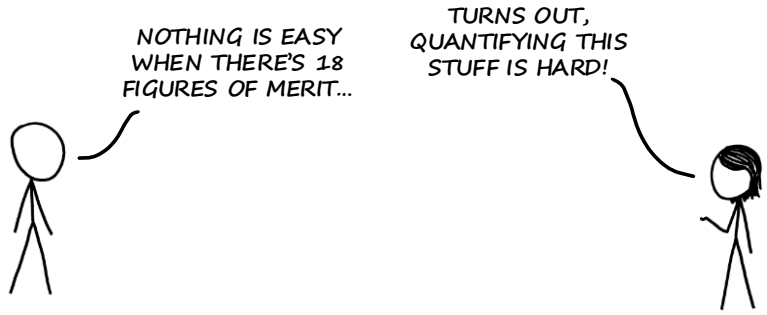
McKinsey & Company

UNDERSTANDING WHAT TO IMPROVE:

LIFE-CYCLE ANALYSIS





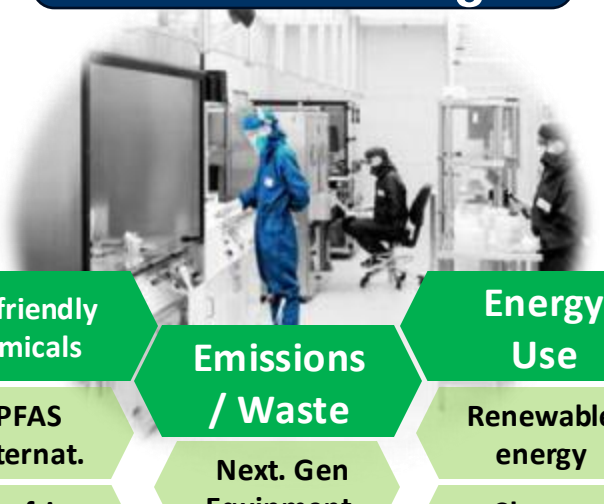


SUSTAINABLE MANUFACTURING

Conventional Manufacturing

- **Toxic Chemicals**
  - Reagents
  - Etchants
  - PFAS
- **Material Waste**
  - Subtractive Processes
  - Single-Use Equipment
  - Waste Water
- **Energy Use**
  - Instrument Operation
  - Envir. Control

Greener Manufacturing

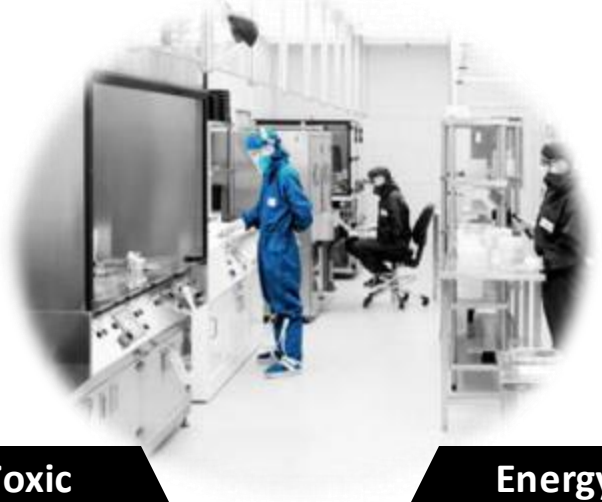


- **Env. friendly Chemicals**
  - PFAS alternat.
  - Env.frien solvents
  - Reuse materials
- **Emissions / Waste**
  - Next. Gen Equipment
  - NextGen. Processes
  - Abatement systems
  - Water Recycling
  - Better filtering
  - Better monitoring
- **Energy Use**
  - Renewable energy
  - Change lighting

Pros	Cons
Lower waste	Still energy consuming
Less emissions	Still make waste
Mid/high performance	Reduced performance
Classical processes	

SUSTAINABLE MANUFACTURING

Conventional Manufacturing



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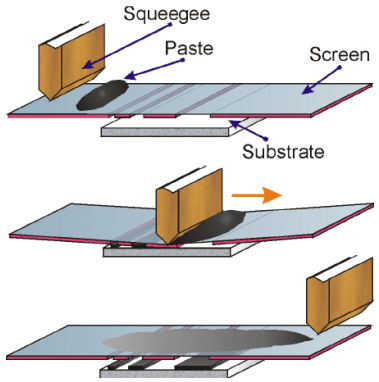
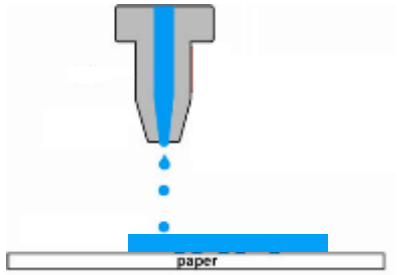
Alternative Manufacturing



Screen Printing (SP)



Inkjet Printing (IJP)

Pros	Cons
Low waste	Feature sizes >1µm
Less energy consuming	Materials integration
Adaptable Designs	Reduced performance
Flexible Substrates	

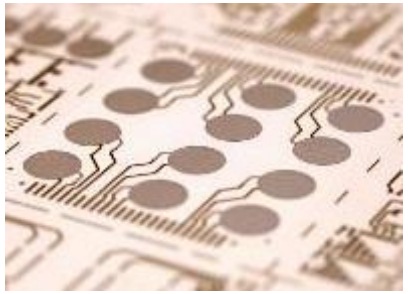


Image from SUPERSMART, an EU project

SUSTAINABLE MANUFACTURING

Conventional/Greener Manufacturing + **Alternative Manufacturing** = **Hybrid Electronics**

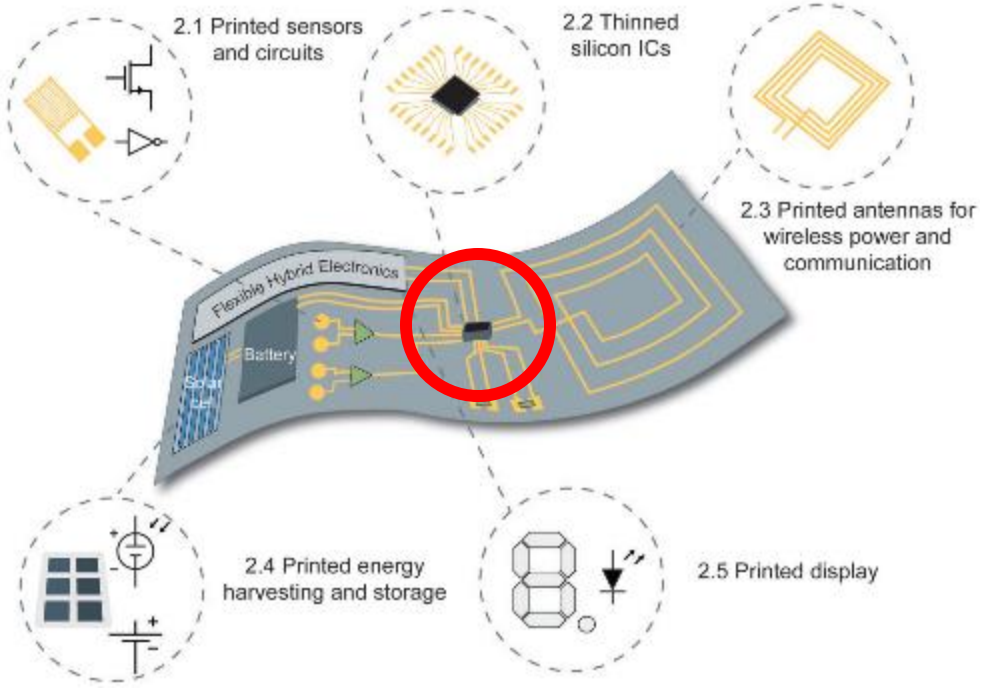


Image from Khan et al 2019

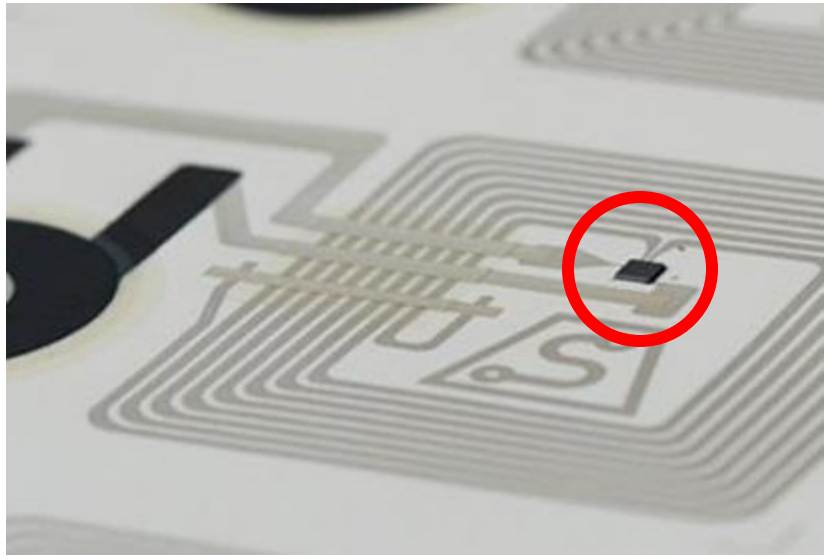


Image from Fraunhofer ISC, CeSMA

PATHS FOR IMPROVING SUSTAINABILITY OF ELECTRONICS

Eliminate non-critical components

Eliminate bulky reader
Switch comms & power to phone

Reduce and miniaturize

Simplify system to only essentials
Minimize # of components

Switch to greener materials and methods

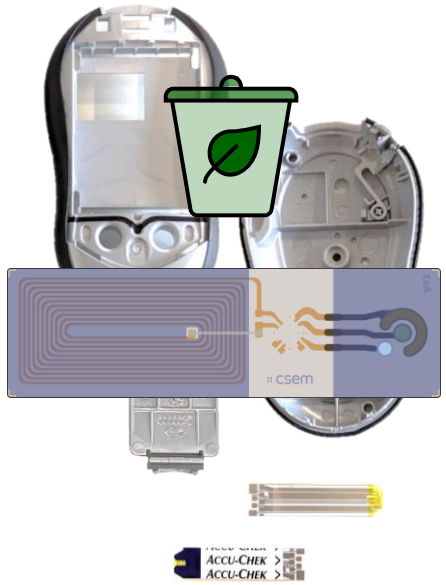
Switch to sustainable packaging
Print antennas & sensors

Design for disassembly, reuse

Make reusable parts easy to recover and recycle

Design for disposability

Make non-reusable parts safe and easy to discard



$m_{glucometer}$ = 60g

m_{SUMON} = 0.23g*

*Without including phone

HE& CHIPS JU PROJECTS ON SUSTAINABLE ECS

E-waste/Circularity

EECONE

CIRC-UITS

TREASURE

Functional electronics

SusFE

ECOTRON

UNICORN

Suink

TESLA
Transient Electronics for Sustainable ICT in Digital Agriculture

Printed electronics

SustrOnics

SUSTAIN A PRINT

SUPERIOT

REFORM

PFAS alternatives

14AMI

SSbD4CheM

BIO-SUSHY

INSIGHT

ZEROF

New biomaterials

CircEl·Paper

HyPELignum

PFAS sensing

BioSensei

compas

Green manufacturing

FASTLANE

REEPRODUCE

PRecycling

Recycling

BATTERY2LIFE

CHIPS JU 2024 Focus Topic:
GENESIS

GREEN ELECTRONICS @ CHIPS JU

	SUSTRONICS	EECONE	GENESIS
	Circular electronic devices Sustainable manufacturing for electronics Environmentally compatible single-use electronics	Reduce, Reliability, Reuse, Repair, Refurbish, Recycle for zero e-waste. Wearable patches, Recyclable batterie, PCBs,…	Generate in EU a sustainable industry for semiconductors
	**Eco-friendly**	**Reduce E-waste**	**Green manufacturing**
	**Eco-design, additive manufacturing, bio-based materials**	**Implementation of 6Rs for electronics design, Design for Disassembly**	**Materials, processes, monitoring, abatement**
	**Chips JU 2022**	**Chips JU 2022**	**Chips JU 2024**
	**Ongoing**	**Ongoing**	**Starting**

SUSTRONICS
Sustainable and green electronics for circular economy

- 46 partners from 11 countries
- 30 industry partners throughout value chain
- 3 Years starting 1.6.2023
- www.sustronics.eu
- Coordinator: Philips, Technical manager: VTT

Ecosystem demonstrating how electronics industry can benefit from sustainability and circularity

3 use cases, 10 pilots, led by industry

Circular electronic devices

Sustainable manufacturing for electronics

Environmentally compatible single-use electronics

42% of consumers prefer **environmentally friendly** electronic devices, but **53%** think there is a financial barrier[1]

Environmental impact of **substrate** can decrease up to **75%** with sustainable alternatives[2]

Status at M18

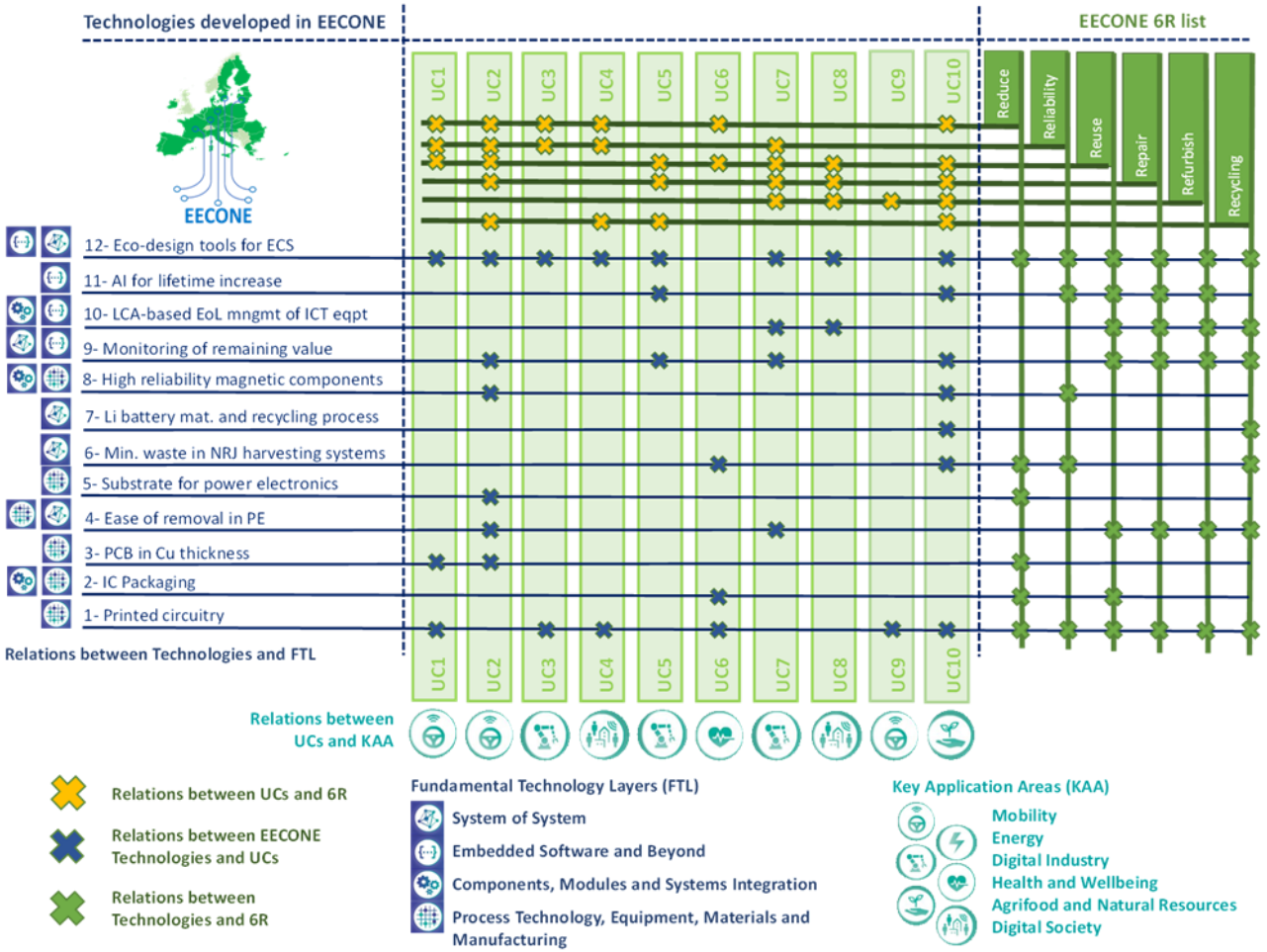
- First prototypes of pilots integrated and their environmental impact calculated
- Development of circular business models on-going to support commercialisation
- New sustainable materials, processes, components and devices available

[1]SUSTRONICS consumer study (1000 consumers from 5 countries)

[2]SUSTRONICS LCA calculations

EECONE – EUROPEAN ECOSYSTEM FOR GREEN ELECTRONICS

- Over 50 partners
- 16 countries
- 3 years starting 01.07.2023
- Coordinator: Infineon



Guided by the 6R principles we develop the technology for a zero-waste future of electronic components and systems.

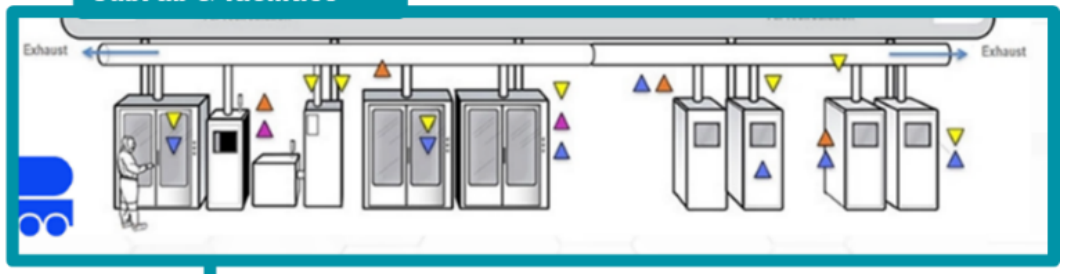
GENESIS - GENERATE IN EUROPE A SUSTAINABLE INDUSTRY FOR SEMICONDUCTORS

- 60 partners from 12 countries
  - 32 industrial and 12 SME partners
  - 9 RTO and 7 academic partners
- 3 Years
- Coordinator: CEA-LETI Support: CSEM

→ Improve the entire manufacturing sustainability chain value

Fab level : process & equipment

SubFab & facilities



1 GASES & CHEMICAL

- PFAS free materials (litho, bonding, eqpt)
- Low GWP gas (etch & clean)

2 PROCESS

- Technology sustainable alternatives (FEOL- BEOL – Packaging)

3 WASTE MONITORING & TREATMENT

- By-products & wastes sensing & monitoring
- Filtration and adsorption solutions (PFAS…)
- Reuse

4 AIR EMISSIONS

- Reduce gas emission
- Abatement
- H2 gas carrier re-use (MOCVD)

5 FINAL TREATMENT

- Reduce aqueous emission
- Water abatement
- Develop CRM recycling & valorization solutions

EPOSS WG GREEN ECS

Materials	Processes	Compo-nents	Integra-tion	Reliabi-lity	Eco-Design	Software	Repair	Standards & regulations
Tyndall	CNM Centro Nacional de Microelectrónica IMB	cea	Fraunhofer ENAS	cea	cea	csem	SIEMENS	microTEC Südwest
CNM Centro Nacional de Microelectrónica IMB	cea	csem	Fraunhofer IZM	Fraunhofer IZM	CNM Centro Nacional de Microelectrónica IMB		infineon	
Fraunhofer ISC	Fraunhofer IZM	life.augmented	life.augmented	Fraunhofer ENAS	Fraunhofer IZM		BOSCH	
SAL SILICON AUSTRIA LABS	csem	VTT	RI.SE	RI.SE	csem			
VTT	life.augmented	Tyndall	VTT	life.augmented	SAL SILICON AUSTRIA LABS			
	VTT		cea		RI.SE			
	SAL SILICON AUSTRIA LABS				life.augmented			
	Tyndall				VTT			

SELECT PROGRAM

SUSTAINABLE ELECTRONICS PROJECTS AT CSEM

CSEM internal

- EFORE (‘23) & ENFRED (‘24) → LCA of PCB and whole IoT device
- SUMON (‘23-’25) → Disposable AND sustainable
- GREENPOCKET (‘23) & COPPERFIELD (‘24) → Feasibility of sustainable AM

Swiss academic and industrial partners

- GREENSPACK (EMPA, EPFL) → Fully biodegradable alternatives
- ELUSIVE (HEArC, Sonceboz) → Triggerable PCB decomposition

EU partners

- SUSTRONICS → Disposable and sustainable alternatives
- EECONE → Hybrid re-use / disposable alternatives
- TESLA → Fully biodegradable alternatives

FACING THE CHALLENGES OF OUR TIME

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