

Symposium “Electronique & numérique durables”

Extension of the Life Cycle Analysis method to an R&D environment, based on the study of a prototype use case.

29/11/2024

Makan (Thibault) HALTER

CEA LIST

Introduction

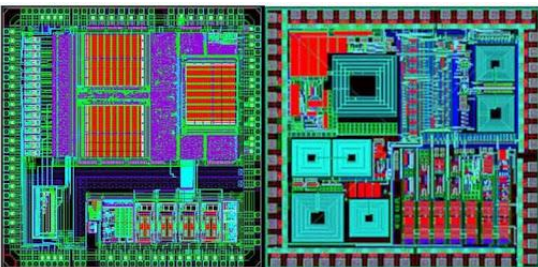


Analogy : Integrated Circuit (IC) and building

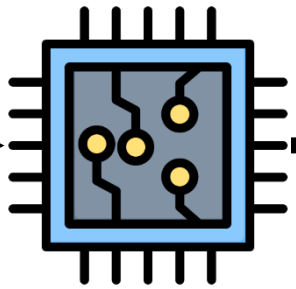
Icon artists :
Zlatko Najdenovski
Monkik
Rasama studio
Uniconlabs
Surang
Candy design



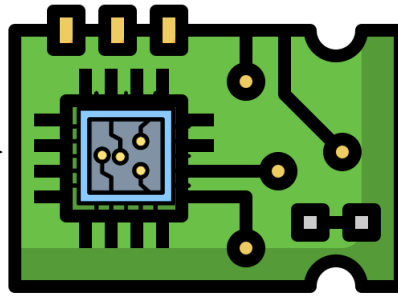
Ecodesign
(Life Cycle Analysis)



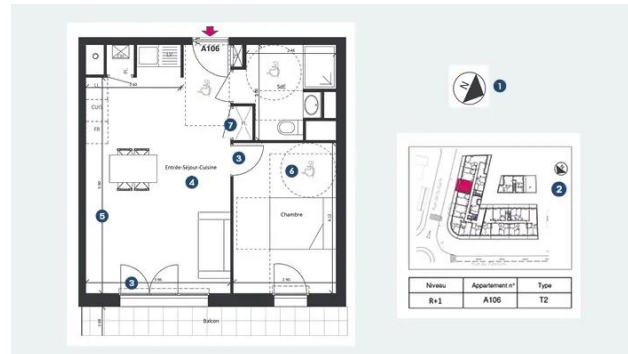
IC Layout



Integrated Circuit [IC]

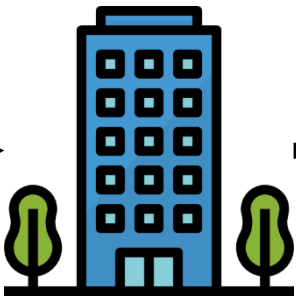


Integration to a specific environment
(PCB + capacitors + unknown ICs + battery + captors...)



Architect building plan

Niveau	Appartement n°	Type
R+1	A106	T2



Building



Integration to a specific environment
(Neighborhood)



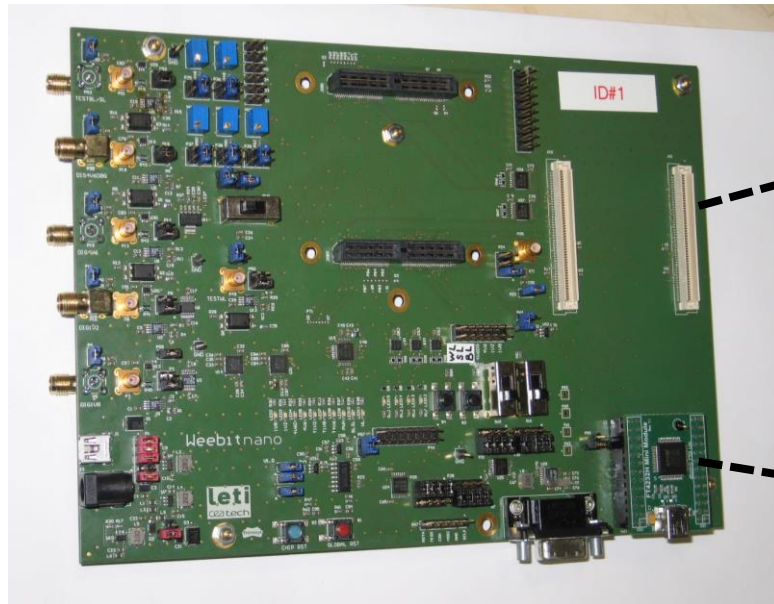
Introduction

Objectives :

- Define **relevant hypothesis & assumptions** that allow to make **systematic numeric LCA from design**

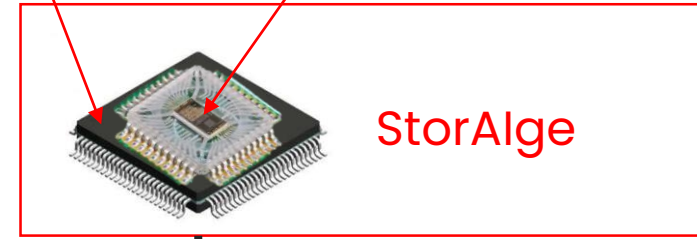
1st steps :

- Exploration work from a usecase : StorAige project (CEA LIST)
- **Prototype testversion** [Extraction & Manufacturing only]



Motherboard

Package IC



StorAige

Maha & al.
"Storage Class Memory with Computing RowBuffer: A Design Space Exploration",
2021



Daughterboard



FTDI Module

Running a LCA from an electronic design



Datas from design

Bill of material (BoM)
>200 components
(ICs, capacitors,
resistors, connectors...)

Component	Type	Description	Quantity	Unit	Material	Weight
IC1	IC	Microcontroller	1	g
IC2	IC	Microcontroller	1	g
IC3	IC	Microcontroller	1	g
IC4	IC	Microcontroller	1	g
IC5	IC	Microcontroller	1	g
IC6	IC	Microcontroller	1	g
IC7	IC	Microcontroller	1	g
IC8	IC	Microcontroller	1	g
IC9	IC	Microcontroller	1	g
IC10	IC	Microcontroller	1	g
IC11	IC	Microcontroller	1	g
IC12	IC	Microcontroller	1	g
IC13	IC	Microcontroller	1	g
IC14	IC	Microcontroller	1	g
IC15	IC	Microcontroller	1	g
IC16	IC	Microcontroller	1	g
IC17	IC	Microcontroller	1	g
IC18	IC	Microcontroller	1	g
IC19	IC	Microcontroller	1	g
IC20	IC	Microcontroller	1	g
IC21	IC	Microcontroller	1	g
IC22	IC	Microcontroller	1	g
IC23	IC	Microcontroller	1	g
IC24	IC	Microcontroller	1	g
IC25	IC	Microcontroller	1	g
IC26	IC	Microcontroller	1	g
IC27	IC	Microcontroller	1	g
IC28	IC	Microcontroller	1	g
IC29	IC	Microcontroller	1	g
IC30	IC	Microcontroller	1	g
IC31	IC	Microcontroller	1	g
IC32	IC	Microcontroller	1	g
IC33	IC	Microcontroller	1	g
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IC75	IC	Microcontroller	1	g
IC76	IC	Microcontroller	1	g
IC77	IC	Microcontroller	1	g
IC78	IC	Microcontroller	1	g
IC79	IC	Microcontroller	1	g
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IC93	IC	Microcontroller	1	g
IC94	IC	Microcontroller	1	g
IC95	IC	Microcontroller	1	g
IC96	IC	Microcontroller	1	g
IC97	IC	Microcontroller	1	g
IC98	IC	Microcontroller	1	g
IC99	IC	Microcontroller	1	g
IC100	IC	Microcontroller	1	g

How to build Life Cycle Inventory from design ?

Case 1:
Non-exhaustive LCA database
Example : Capacitor

Case 2:
Lack of precision in BoM and industrial datasheets
Example : unknown ICs

LCA software

EIME

Database [Secondary data]

CODDE
Negaoctet

Methodology

EF 3.0

LCA Hypothesis

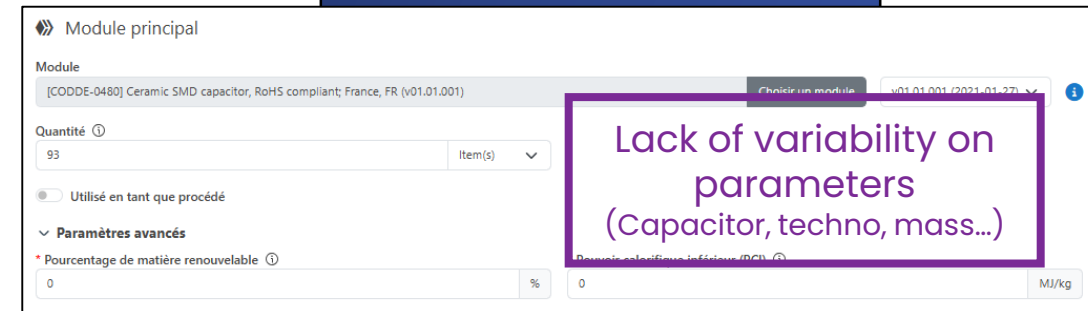
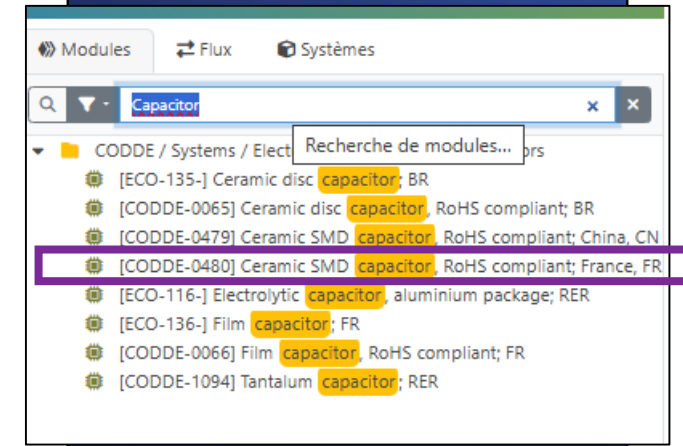
Case 1: Non-exhaustive LCA database – Example of Capacitors

Datas from design

1uF	1uF	Capacitor (Semiconductor SIM Model)
10uF	10uF	Capacitor (Semiconductor SIM Model)
10uF		Polarized Capacitor TPSA105K020R3000
4.7uF	4.7uF	Capacitor (Semiconductor SIM Model)
10nF	10nF	Capacitor (Semiconductor SIM Model)
100nF	100nF	Capacitor (Semiconductor SIM Model)
330nF	330nF	Capacitor (Semiconductor SIM Model)
2.2uF	2.2uF	Capacitor (Semiconductor SIM Model)
220nF	220nF	Capacitor (Semiconductor SIM Model)
470nF	470nF	Capacitor (Semiconductor SIM Model)

LCA software

EIME



LCA Hypothesis

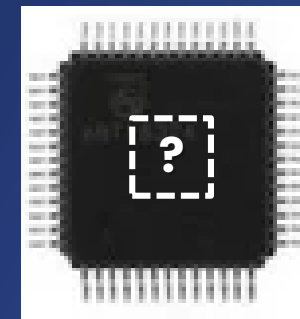
Case 2: Lack of precision in BoM and industrial datasheets – Example of unknown ICs

Datas from design

LCA software

EIME

IC Dimensions



Technology node

28 nm – 50 masks

45 nm – 42 masks

65 nm – 38 masks

90 nm – 33 masks

130 nm – 29 masks

Manufacturing location

China
Taiwan
Europe&Usa

LCA Hypothesis

Case 2: Lack of precision in BoM and industrial datasheets – Example of unknown ICs

Datas from design

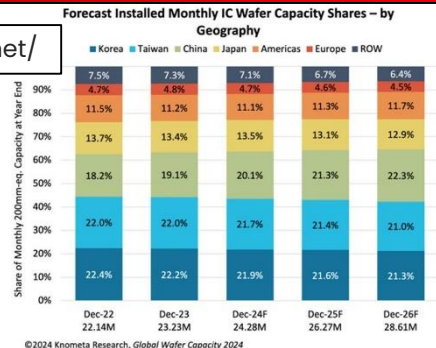
Hypothesis :

50 % Package dimension
(Uncertainty scenarios :
20% and **80%**)

Hypothesis :

Mix from **28nm** to **130nm**

<https://vipress.net/>

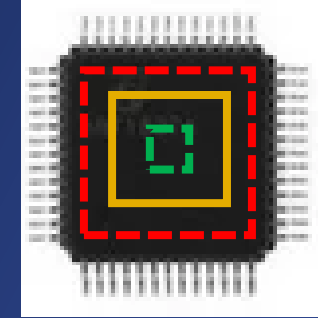


Refers to annual production data from 2022 to 2024

LCA software

EIME

IC dimension



Technology node

20 %	28 nm – 50 masks
20 %	45 nm – 42 masks
20%	65 nm – 38 masks
20%	90 nm – 33 masks
20%	130 nm – 29 masks

Manufacturing location

China : 23%,
Taiwan&Japan : 61%,
Europe&Usa : 16%

Concordance of LCA model

➤ Problem :

➤ System mass = **237 g**

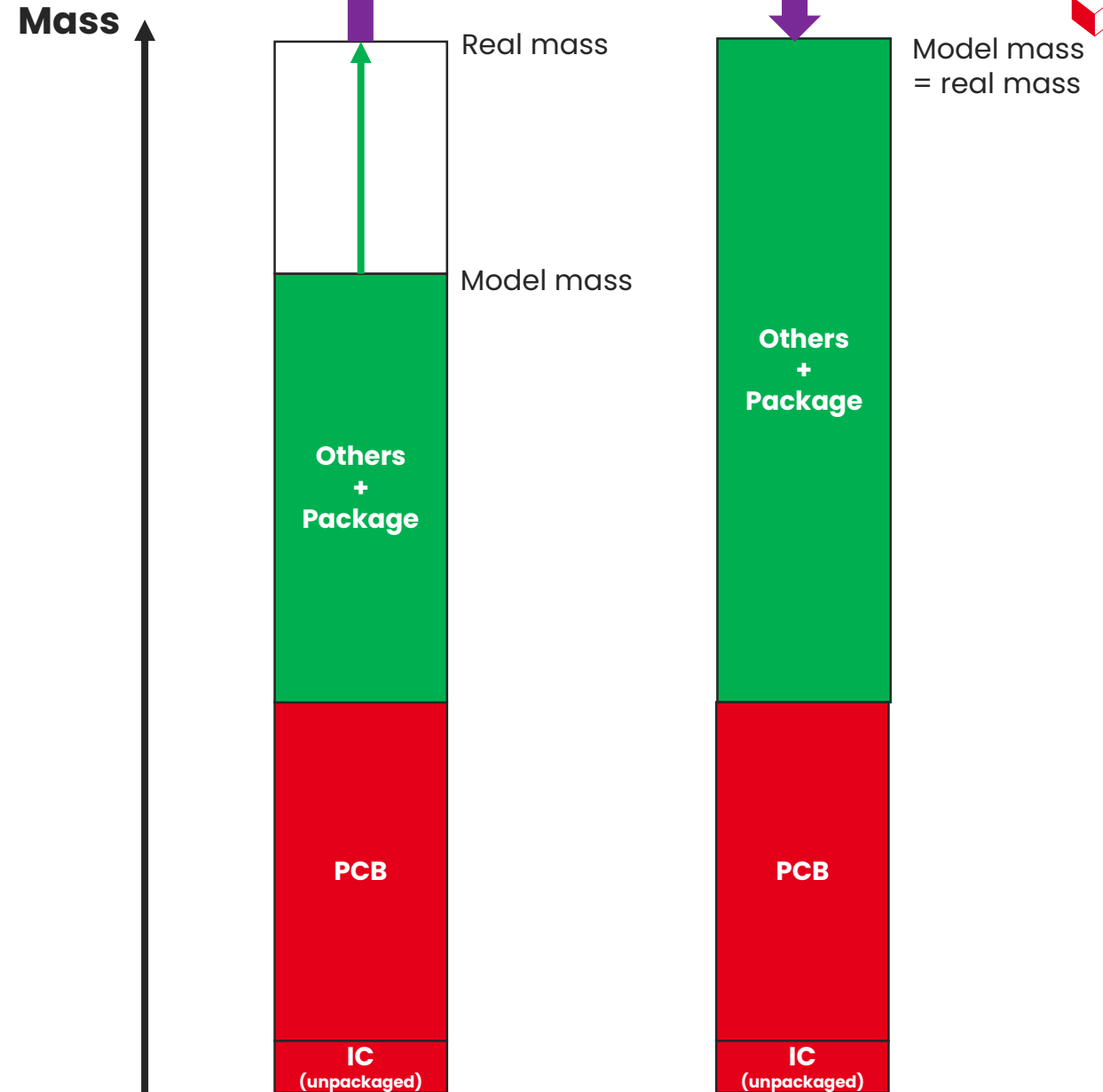
➤ Model mass = **182 g (76%)**

Error might come from **datasheets**

→ **Underevaluation of impacts**

➤ Solution : Bring back model **impacts up to 100%**

Not concerned : PCB & Digital IC



LCA Results

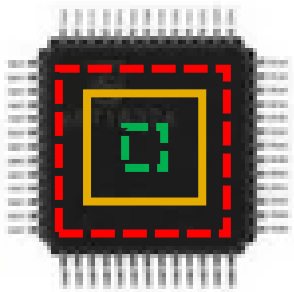
Results for
IC Area = 50%PackageSize

Total mass = 237 g

Emit ~15 kg CO2eq
(Between 11 kg and 18 kg)

Only for **manufacturing**

Uncertainties :
Ic Area = 80%PackageSize
IC Area = 20%PackageSize



Global impacts = +/- 20%

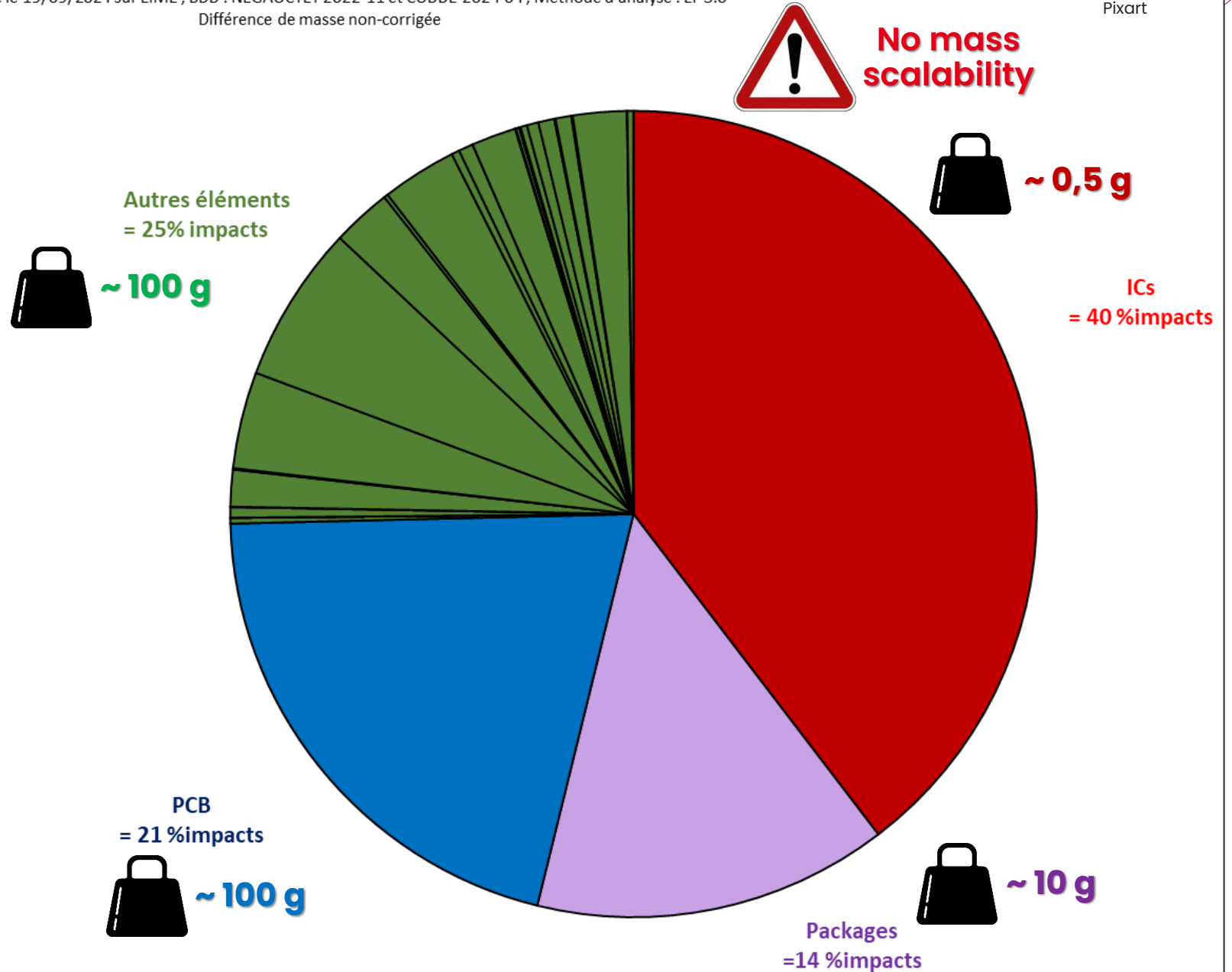


= pondération de l'ensemble des 16 catégories d'impacts

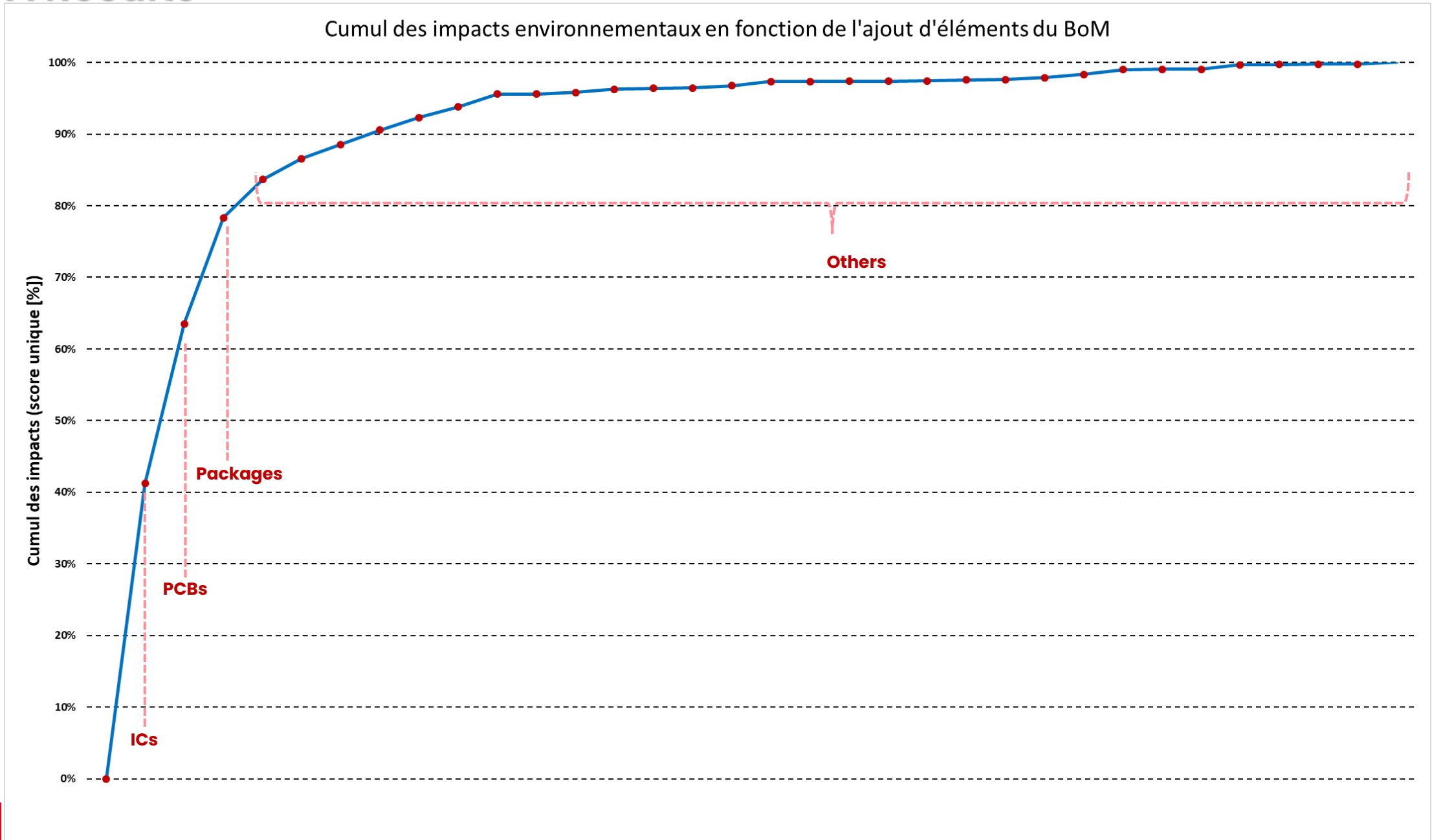
Résultats (en score unique) Manufacturing système StorAlge

ACV réalisée le 19/09/2024 sur EIMV, BDD : NEGACCTET 2022-11 et CODDE-2024-04 ; Methode d'analyse : EF 3.0
Différence de masse non-corrigée

Icon artist :
Pixart



LCA Results



Most valuable data from design to LCA



	Most valuable data	Remarks / perspective
System Generalities	System total mass	For concordance of model
IC	Technology node or number of Mask IC area ~ IC to package ratio	Main Hotspot (most impactful component)
Package	Package technology Mass Number of input/output	
PCB	PWB Technology (FR2,3,4 or CEM1) Dimensions Number of layers	2nd Hotspot
Others components	Bill of Materials Errors from datasheets (mass, dimensions, techno...)	Problem : transposition of BoM to model is the most time consuming and need human intervention

Future works



Next steps of the exploration work :

- **Mapping** dimension[%] of **IC area** VS **package techno**
- Investigation of a **generics BoMs/cm²PCB**
- Extend the LCA to an **industrial version**
- Extend the scope to **usephase, transport** and **end of life**

Automation of LCA :

- Execute **parametric LCA template** from design informations
- **Appa LCA** : open-source LCA tool to be easily integrated to **IC design flow**
 - Poster of this tool in symposium

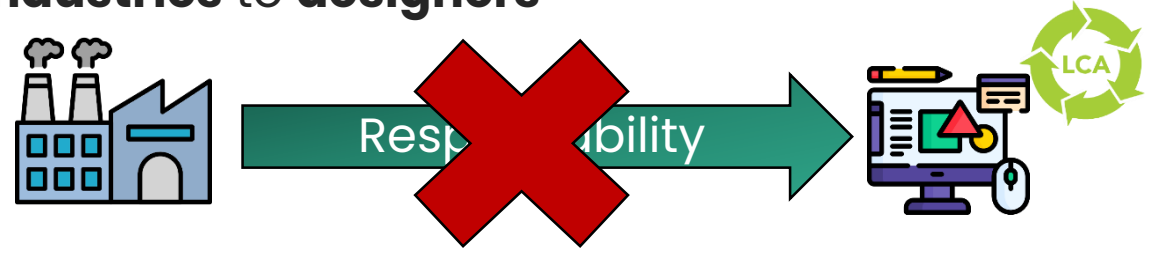


Attention points



We shall not

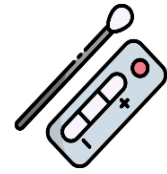
- Transfer the **environmental responsibility** from **industries** to **designers**



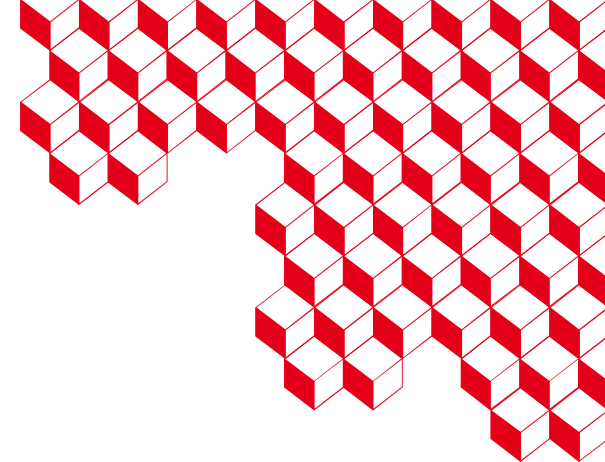
We have to

- Talk more about **sobriety & performance needs**
- Start to think from **specifications** about **rebound effect and** the **relevance of using a too powerful IC**

Do we really need IC in : rearview mirrors, disposable medical self-test, washbasin, etc. ?



Icon artists :
 Freepik
 Bearicons
 Assia Benkerroum



Thanks for your attention 🎵 🎵
Questions ?

Aknowledgments :

Jérémy BALLESTER, Mikael LE COADOU, Jean-Philippe NOEL, Maria RAMIREZ-CORRALES, Bénédicte ROBIN, Maxime PÉRALTA

CEA LIST