

# Sustainable Artificial Intelligence

SusAI Project - 2023  
R&I – Applied AI program

Capgemini  engineering



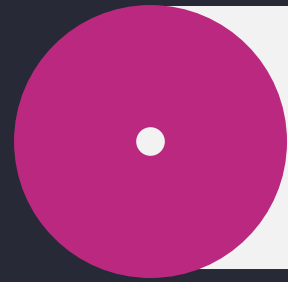
**Etat de l'art :  
Constats & Motivations**



**SusAI :  
Scope & Méthodologie**



**SusAI project :  
Cas d'application**



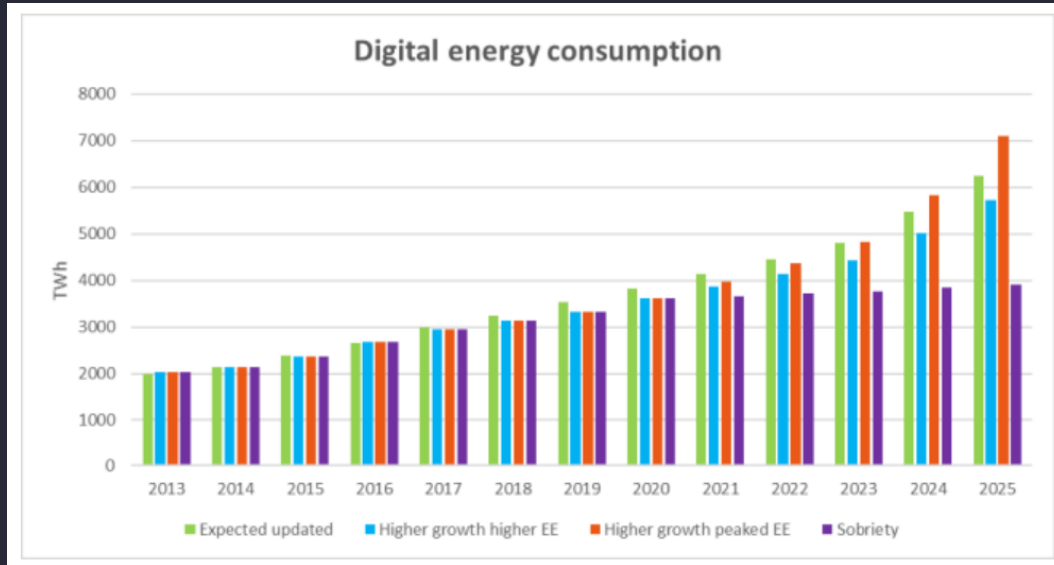
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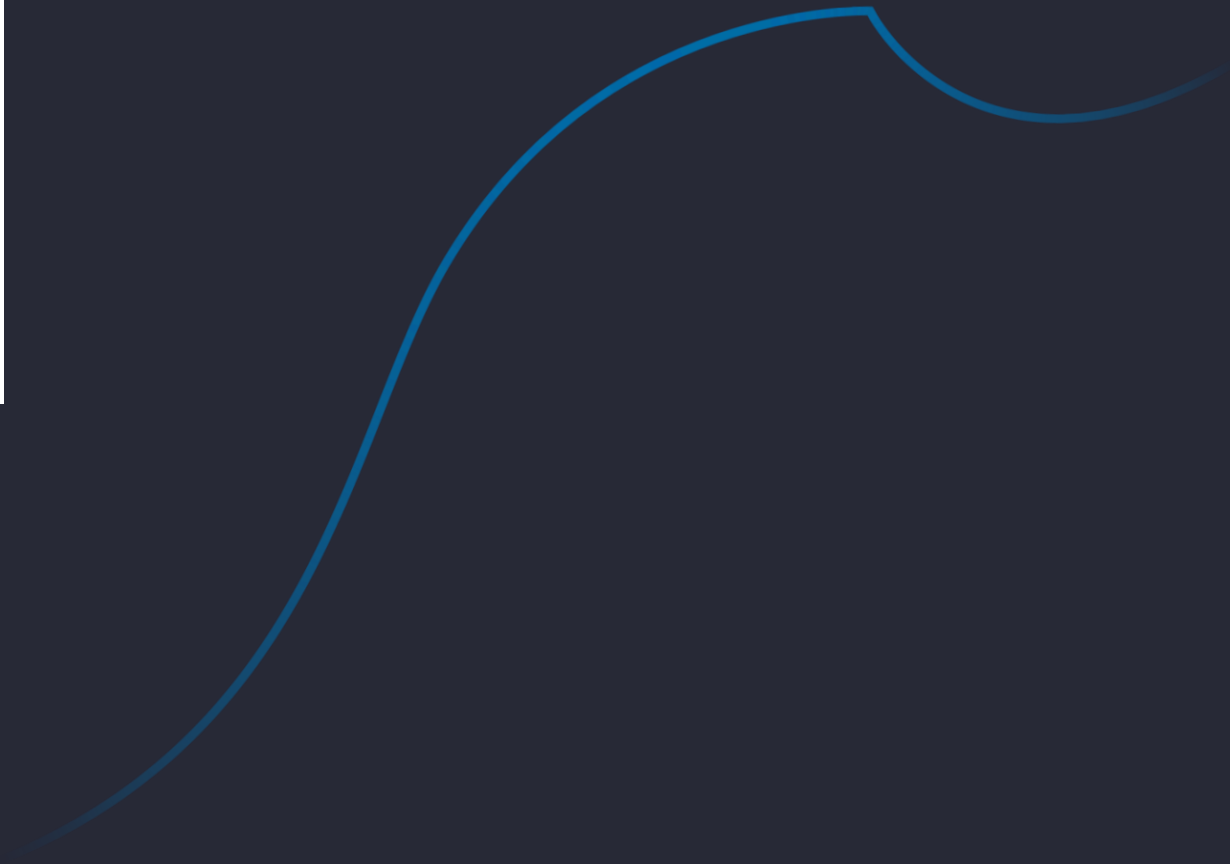
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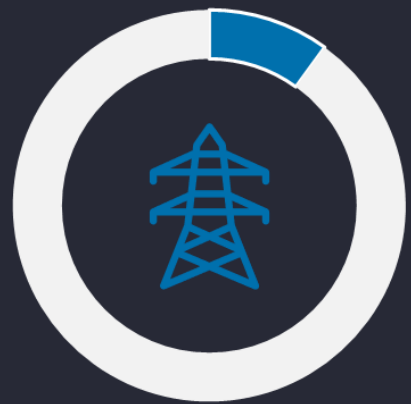


# Le numérique

# 3,5% des émissions GES

[The shift project report](#), 2018





**10%**  
À l'échelle  
mondiale



**+ 9%**  
Chaque année



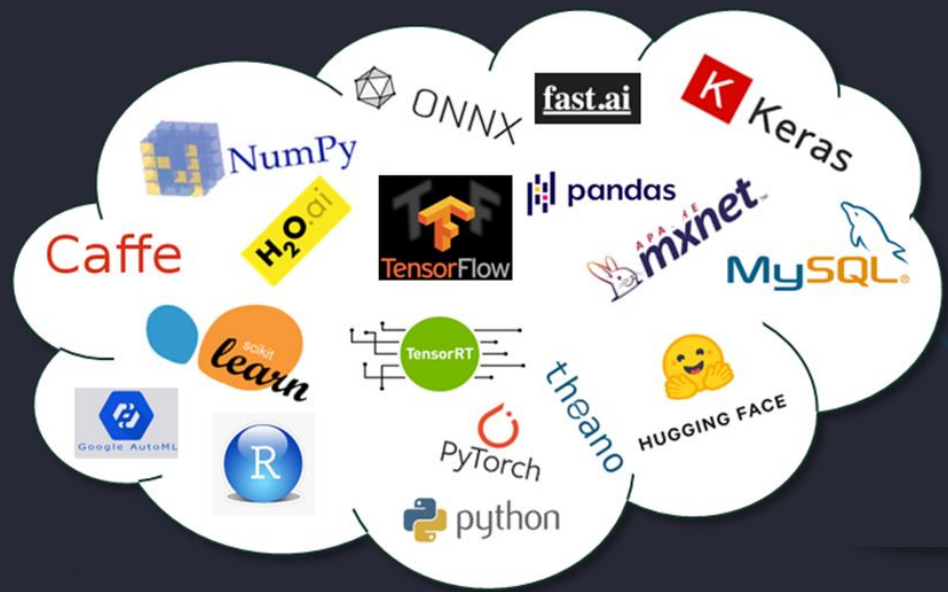
# 70%

Des entreprises  
deploieront au moins une  
solution d'IA à l'échelle  
d'ici **2030**

[McKinsey Global institute report](#), 2019



# Libraries

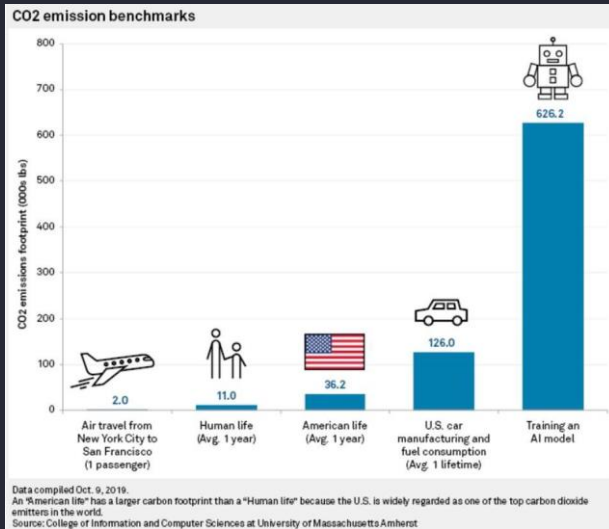


# Données



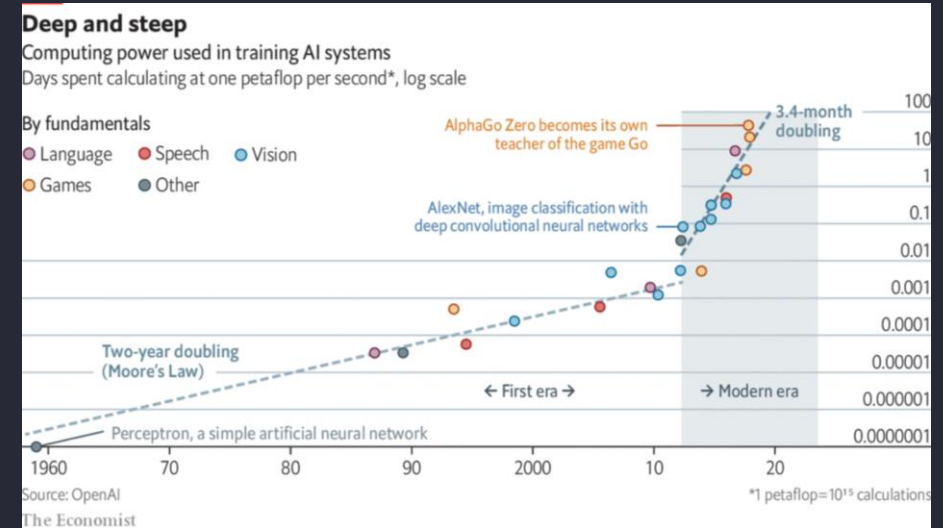
# Puissance computationnelle





**300t de CO<sub>2</sub>**  
Entraînement d'un  
algorithme de NLP

[Strubell E. et al., 2019](#)



Energie pour entrainer un  
algorithme IA a été multiplié par  
**300 000 en 6 ans**

[Amodei. et al., blog post , 2018](#)

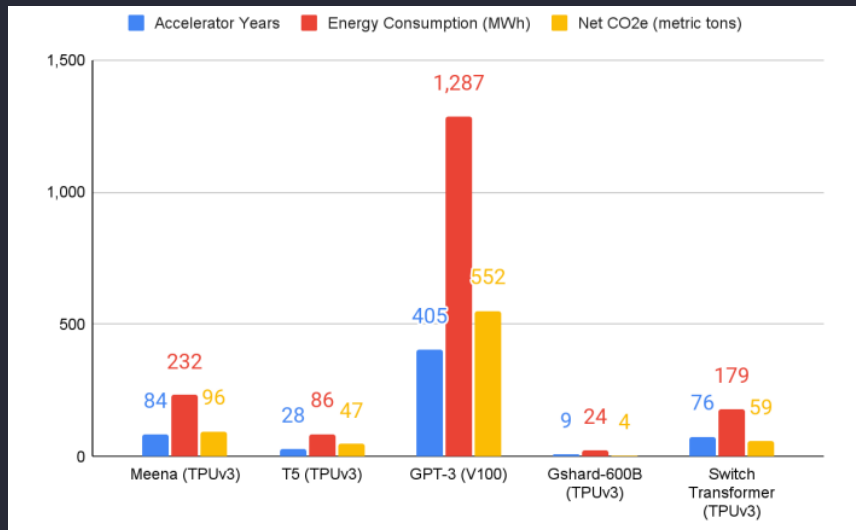




# ChatGPT

**100M** utilisateurs en 2 mois  
**13M** visiteurs / jour

[Blog post](#), 2023



**552t de CO<sub>2</sub>**  
1 entraînement de GPT3

[Patterson et al.](#), 2021



## ACCURATE DRIVEN AI

### Définition

Une AI où la précision est le facteur le plus important au-delà des coûts computationnels et environnementaux

### Caractéristiques

- Modèles volumineux : FLOPS et paramètres élevé
- Précision la plus haute
- Consommation énergétique / impact environnemental élevées

## EFFICIENT DRIVEN AI

### Définition

Une AI où la précision est l'un des paramètres à optimiser tout en minimisant les coûts financiers, computationnels et environnementaux

### Caractéristiques

- Modèles plus légers : FLOPS et paramètres réduits
- Précision acceptable au regard de la cible
- Consommation énergétique / impact environnemental réduits



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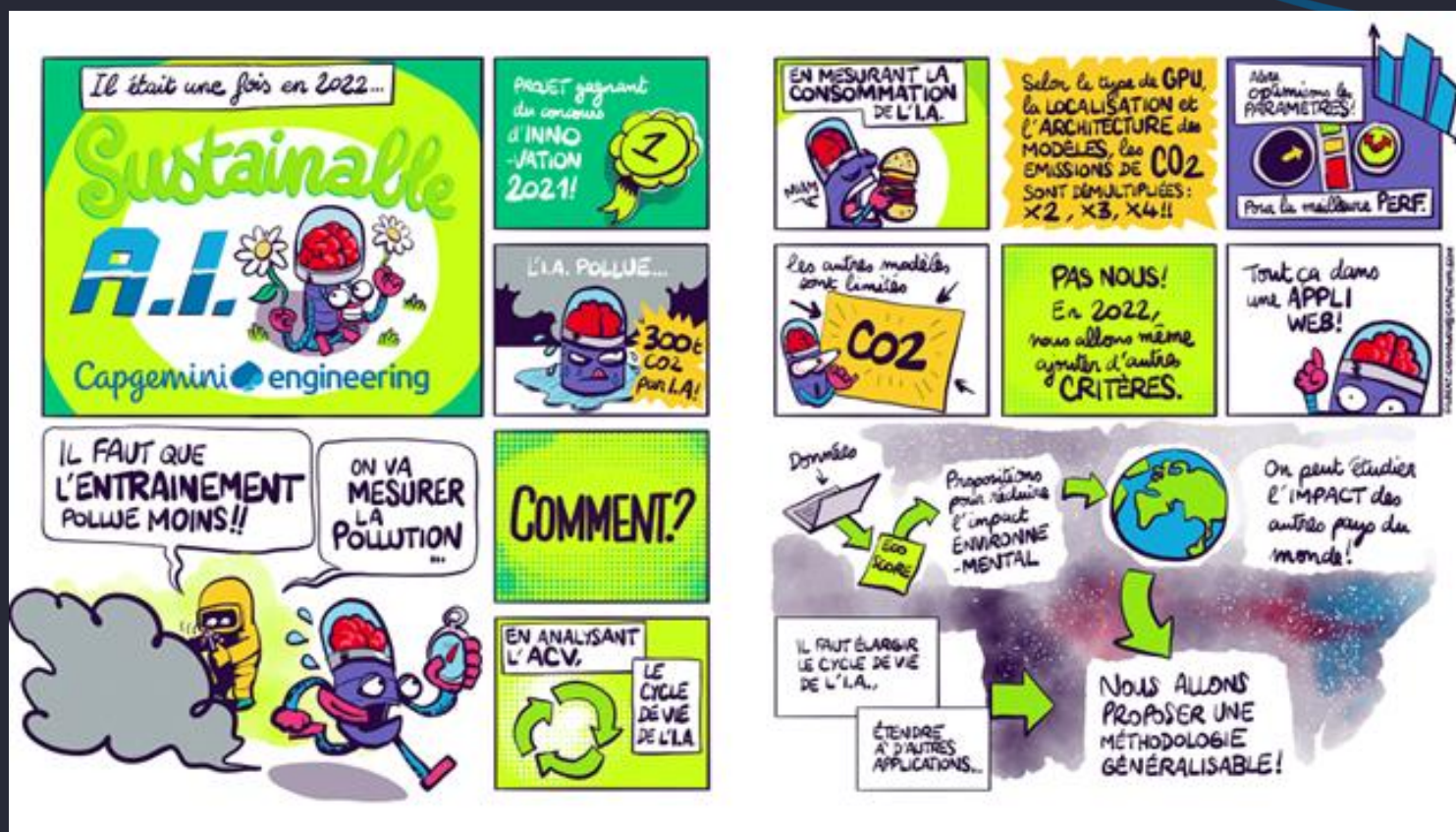


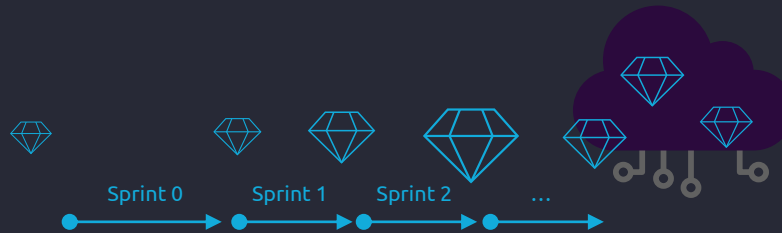
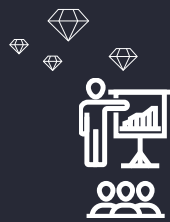
SusAI project :  
Cas d'application



# SusAI

Objectif : **Evaluer** et **réduire** l'impact environnemental des solutions d'IA afin de définir des **bonnes pratiques** en matière d'IA plus durable





- 1 STRATEGIE SPECIFICATION
- 2 CONCEPTION
- 3 IMPLEMENTATION ENTRAINEMENT & TESTS
- 4 DEPLOIEMENT Ux/UI
- 5 UTILISATION

**ECO CONCEPTION, MONITORING ET RÉDUCTION**  
**SusAI**



# SusAI

## Software

## Méthodologie

## Référentiel

GreenAIdvisor  
(App. Web)

GreenAIvaluator  
(App. Web)

SusAI, toolkit

Modèles  
prédictifs, éco-  
score

Analyse du Cycle  
de Vie (ACV)

Bonnes pratiques  
d'eco-conception  
en AI

Impact  
environnemental

Energie  
consommée



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# OUTIL EXISTANT

**ML CO2 Impact** Compute Publish Learn Act About

## Machine Learning Emissions Calculator

Choose your hardware, runtime and cloud provider to estimate the carbon impact of your research.

This calculator will give you 2 numbers: the **raw** carbon emissions produced and the approximate **offset** carbon emissions. The latter number depends on the grid used by the cloud provider and we are open to update our estimates if anything looks inaccurate or outdated.

*Missing a Hardware or a region? Open an issue or a PR on [Github](#)*

Hardware type: A100 PCIe 40/80C  
 Hours Used: 100  
 Provider: Google Cloud Plat  
 Region of Compute: asia-east1

**COMPUTE**

- Pas de proposition pour diminuer l’empreinte carbone
- Pas de prise en compte d’autres critère d’impact

# NOTRE OUTIL

	Market	2021	2022	2023
Carbon footprint	✓	✓	✓	✓
Eco conception		✓	✓	✓
Pedagogic tool		✓	✓	✓
Eco-score		⚠	⚠	✓
Include other impact criteria (LCA)		⚠	⚠	✓
Cover all AI applications (CV, NLP, Speech, ...)	⚠		⚠	⚠
Full LCA				⚠

### How to improve your ecoscore:

If you modify the parameters below, you can **REDUCE** your environmental impact by **52%**.

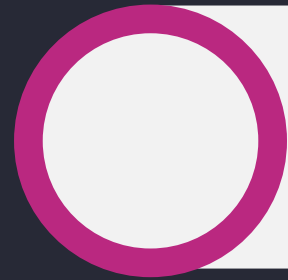
Your scenario	New scenario
Computer vision	-
Classification	-
AWS	-
EfficientNetB5	DenseNet201
20000 images	-
Keras	-
Tesla T4	-
China, China	Leinster, Ireland

**97.84 g eq. CO2** (Your ecoscore) vs **0.2 kWh** (New improved ecoscore)

Grading: A+, A, B, C, D, E. Your current score is D+, the new score is A+.

**Understand the calculation**

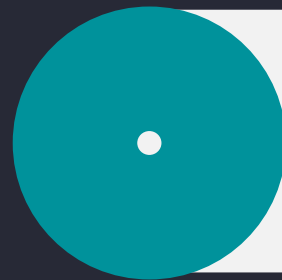




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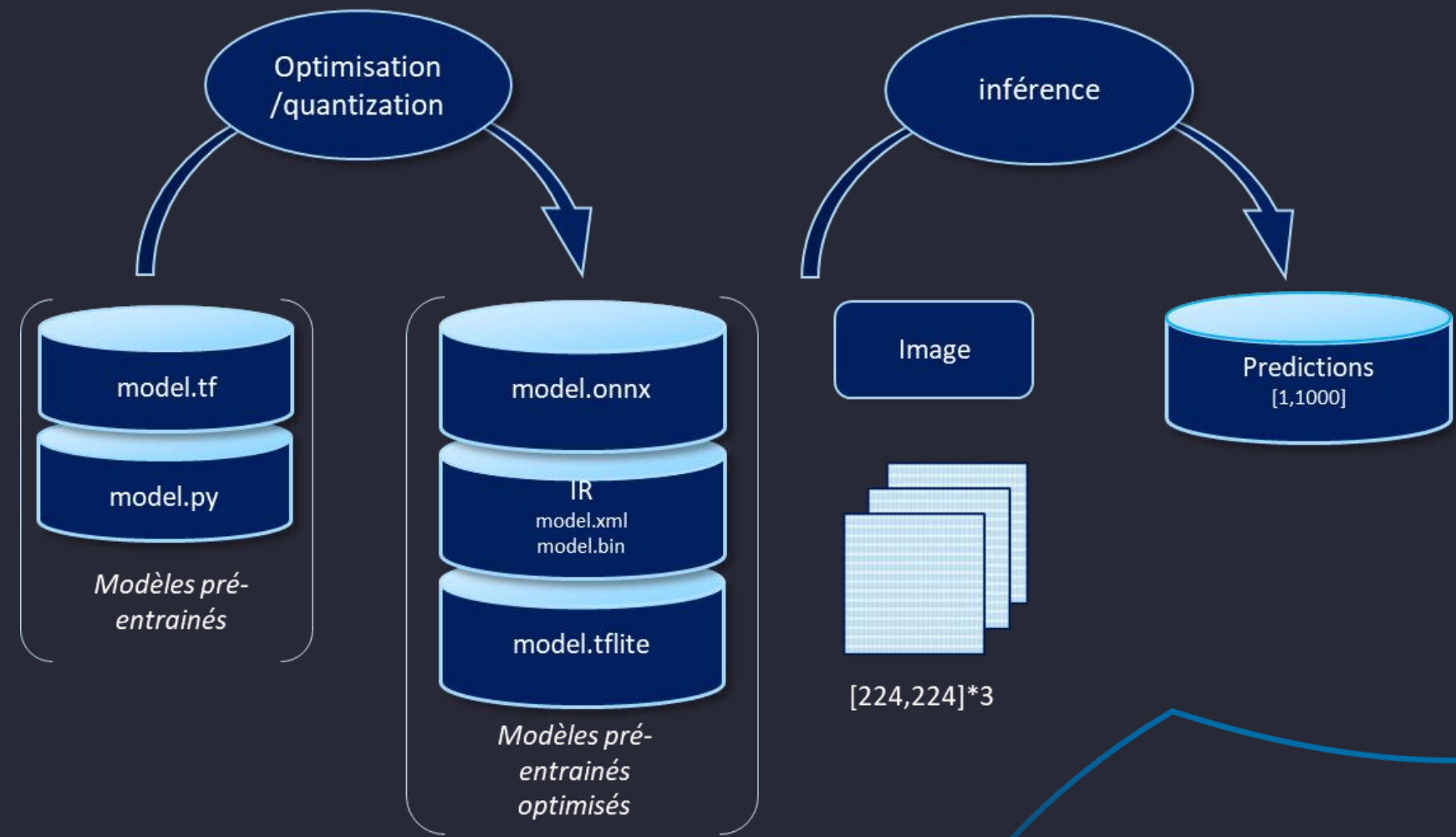
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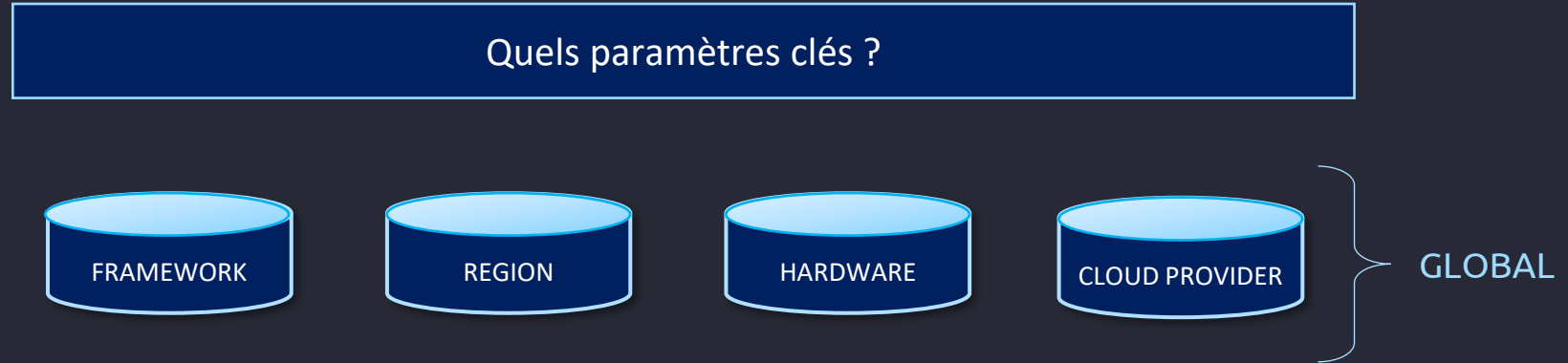


# INFERENCE





# METHOLOGIE





# METHOLOGIE

Quels paramètres clés ?

FRAMEWORK

REGION

HARDWARE

CLOUD PROVIDER

GLOBAL

QUANTIZATION

NB ITERATIONS

TAILLE BATCH

MODELES

FRAMEWORK



# METHOLOGIE

Quels paramètres clés ?

FRAMEWORK

REGION

HARDWARE

CLOUD PROVIDER

GLOBAL

QUANTIZATION

NB ITERATIONS

TAILLE BATCH

MODELES

FRAMEWORK

FLOPS

NB PARAMETRES

ARCHITECTURE

PROBABILITES

MODELE

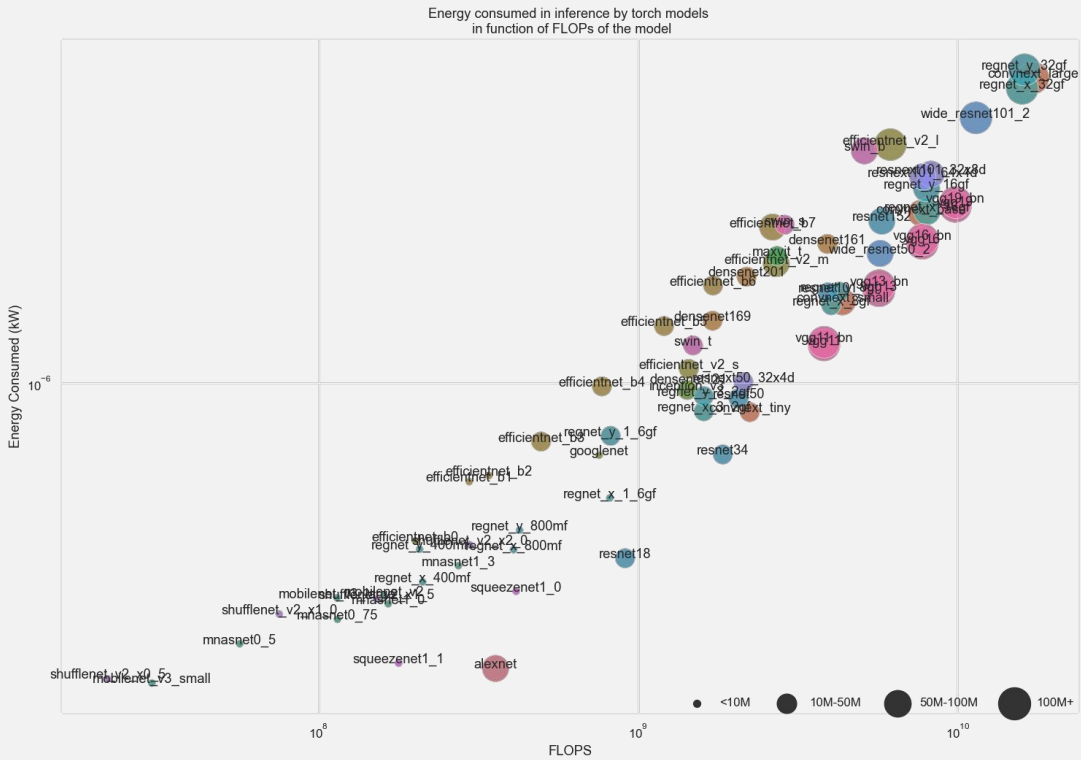
CONSO. NRJ

% UTILISATION  
HARDWARE

DUREE

EMISSIONS CO<sub>2</sub>

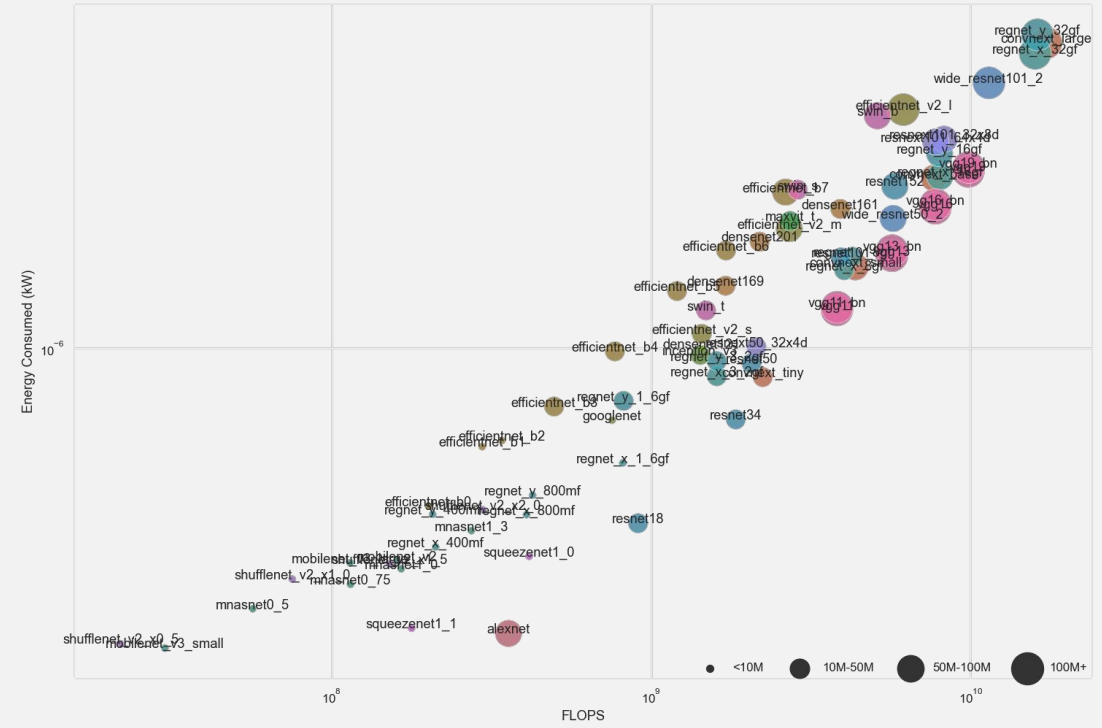
# RESULTS



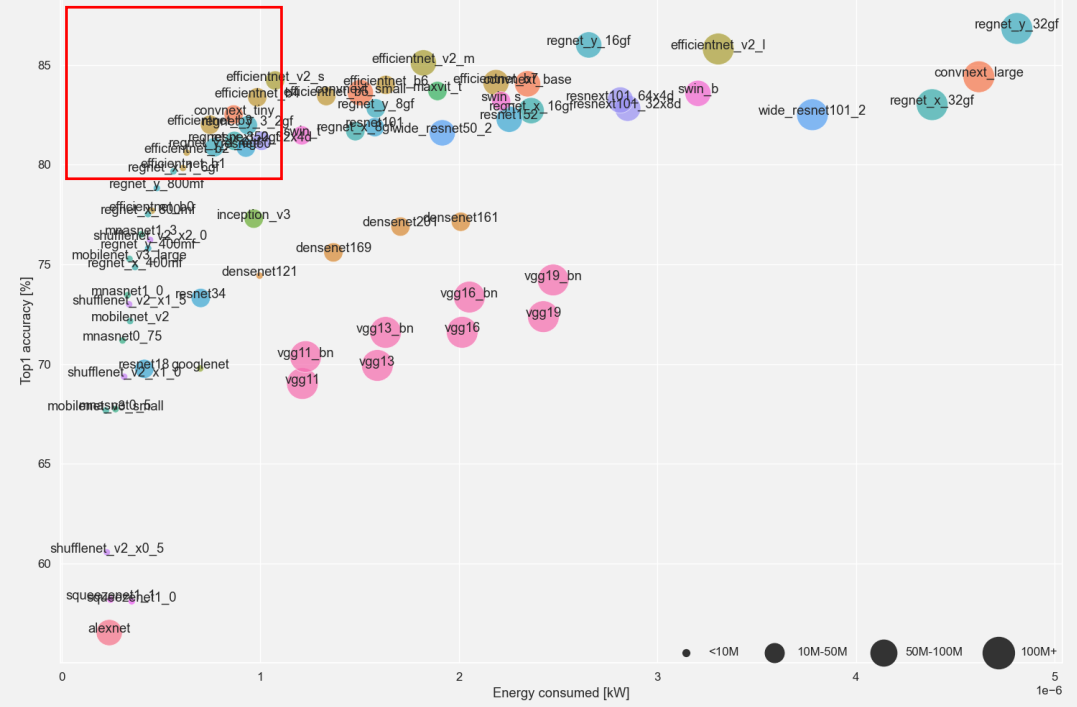


# RESULTS

Energy consumed in inference by torch models in function of FLOPs of the model



Top1 accuracy in inference by torch models in function of energy consumed by the model





# PERSPECTIVES FOR 2023



## R&I

- Définir un **éco-score** et de nouvelles **métriques** pour la performances des algorithms IA
- Etendre à d'autres cas d'applications (**NLP**) : sur **AWS** et avec le **GENCI**
- Poursuivre le travail avec l'INR autour d'une démarche **Numérique Responsable** centrée sur l'IA
- Développer de nouveaux outils et bibliothèques pour **mesurer** et **réduire** la **consommation énergétique** d'une solution IA et évaluer la **maturité** en terme de **NR** d'un projet IA (de la Stratégie à l'utilisation)



## Business

- Deployer nos solutions **en interne** pour tous les projets d'IA et proposer notre expertise aux clients
- Développer des **partenariats externes**
  - Avec le secteur publique (ANITI / LNE) et poursuivre avec l'INR





**Maya  
GUILLAUMONT**

**CER&D**

Projet manager  
Sustainable AI

[maya.guillaumont@capgemini.com](mailto:maya.guillaumont@capgemini.com)



**Hugo  
MARTIN**

**CER&D**

Projet manager  
Sustainable AI



**Antoine  
GAGET**

**CER&D**

Program AAI manager



**Benjamin  
DEGUILHEM**

**CER&D**

Scientific leader R&I



**R&I  
contributors**

Capgemini Engineering

- PMO (Aude Sagnier)
- ACV
- Deep Learning
- Data science
- Dev Web...



**Vincent DE  
MONTALIVET**

**I & D**

Offer leader  
"Sustainable AI"  
Project Sponsor



**Skander  
GUETARI**

**CIS**

Director enterprise  
cloud provider  
Innov4ALL Sponsor



**Guillaume  
HELIAS**

**Capgemini  
Engineering**

Practice manager  
"business" Sponsor



## About Capgemini Engineering

Capgemini Engineering combines, under one brand, a unique set of strengths from across the Capgemini Group: the world leading engineering and R&D services of Altran – acquired by Capgemini in 2020 - and Capgemini's digital manufacturing expertise. With broad industry knowledge and cutting-edge technologies in digital and software, Capgemini Engineering supports the convergence of the physical and digital worlds. Combined with the capabilities of the rest of the Group, it helps clients to accelerate their journey towards Intelligent Industry. Capgemini Engineering has more than 52,000 engineer and scientist team members in over 30 countries across sectors including aeronautics, automotive, railways, communications, energy, life sciences, semiconductors, software & internet, space & defence, and consumer products.

Capgemini Engineering is an integral part of the Capgemini Group, a global leader in partnering with companies to transform and manage their business by harnessing the power of technology. The Group is guided every day by its purpose of unleashing human energy through technology for an inclusive and sustainable future. It is a responsible and diverse organization of 270,000 team members in nearly 50 countries. With its strong 50-year heritage and deep industry expertise, Capgemini is trusted by its clients to address the entire breadth of their business needs, from strategy and design to operations, fueled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering and platforms. The Group reported in 2020 global revenues of €16 billion.



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