AI 4 UNI

Green AI

Dr Tymoteusz Miller

University of Szczecin

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové
Faculty of Informatics and Management

Co-funded by the European Union

Green AI: Navigating the Environmental Impact of Artificial Intelligence

As artificial intelligence accelerates across every sector, its environmental cost is becoming impossible to ignore. This presentation examines AI's growing energy hunger, the e-waste crisis, the unique impact of generative AI, and what users and developers can do to build a more sustainable digital future.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

CHAPTER 1

The Unseen Footprint of AI

Behind every AI query, recommendation, and generated image lies a vast industrial infrastructure consuming water, electricity, and rare materials at scale. Before we can address AI's environmental cost, we must first make it visible.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové
Faculty of Informatics and Management

Co-funded by the European Union

AI's Growing Thirst: Electricity Consumption

2x

Data Center Energy

Global data center electricity use is predicted to nearly double between 2022 and 2026, driven largely by AI workloads.

11x

AI Compute Demand

Global electricity demand for AI computing is expected to be 11 times higher in 2030 than it was in 2023.

2030

U.S. Data Centers

By 2030, U.S. data centers may consume more electricity than the entire energy-intensive goods production sector combined.

These projections underscore a structural challenge: AI's energy appetite is growing faster than the grid's capacity to supply it cleanly. Without intervention, the carbon footprint of AI risks undermining global climate commitments.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

The Scale of AI Models: From Billions to Trillions

Exponential Parameter Growth

The number of parameters in AI models has surged from **1.5 billion** in GPT-2 (2019) to an estimated **2 trillion** in LLaMA 4 (2025). Each parameter requires memory, compute, and energy — multiplied across billions of inference requests daily.

This explosion in model size directly correlates with dramatic increases in training energy costs, water usage for cooling, and the volume of specialized hardware required.

The Doubling Cadence

The computational effort required to train frontier AI models doubles approximately every **five months** — a pace far outstripping improvements in hardware efficiency. Even as individual chips become more efficient, the sheer scale of new models erases those efficiency gains entirely.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové
Faculty of Informatics and Management

Co-funded by the European Union

AI's Insatiable Appetite

Every AI interaction — from a search query to a generated image — triggers energy-intensive compute cycles across distributed data centers. The infrastructure required is staggering in scale, and it is growing.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové
Faculty of Informatics and Management

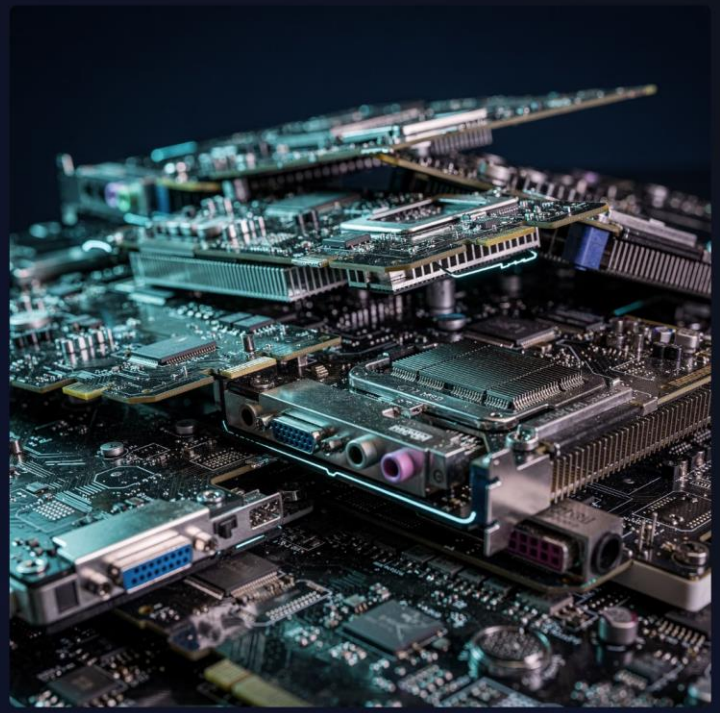
Co-funded by the European Union

The E-Waste Crisis: AI's Disposable Hardware

The World's Fastest-Growing Waste Stream

Electronic waste is already recognized globally as the **fastest-growing waste stream**, with tens of millions of metric tons generated annually. AI is accelerating this trend, as rapid model iteration drives equally rapid hardware replacement cycles — GPUs, TPUs, and custom accelerators become obsolete within years, sometimes months.

Unlike traditional electronics, AI-specific chips often contain rare earth materials that are extremely difficult and costly to recover through recycling.



Manufacturing Impact

Producing AI chips requires energy-intensive semiconductor fabrication, contributing significant carbon before a single inference is run.

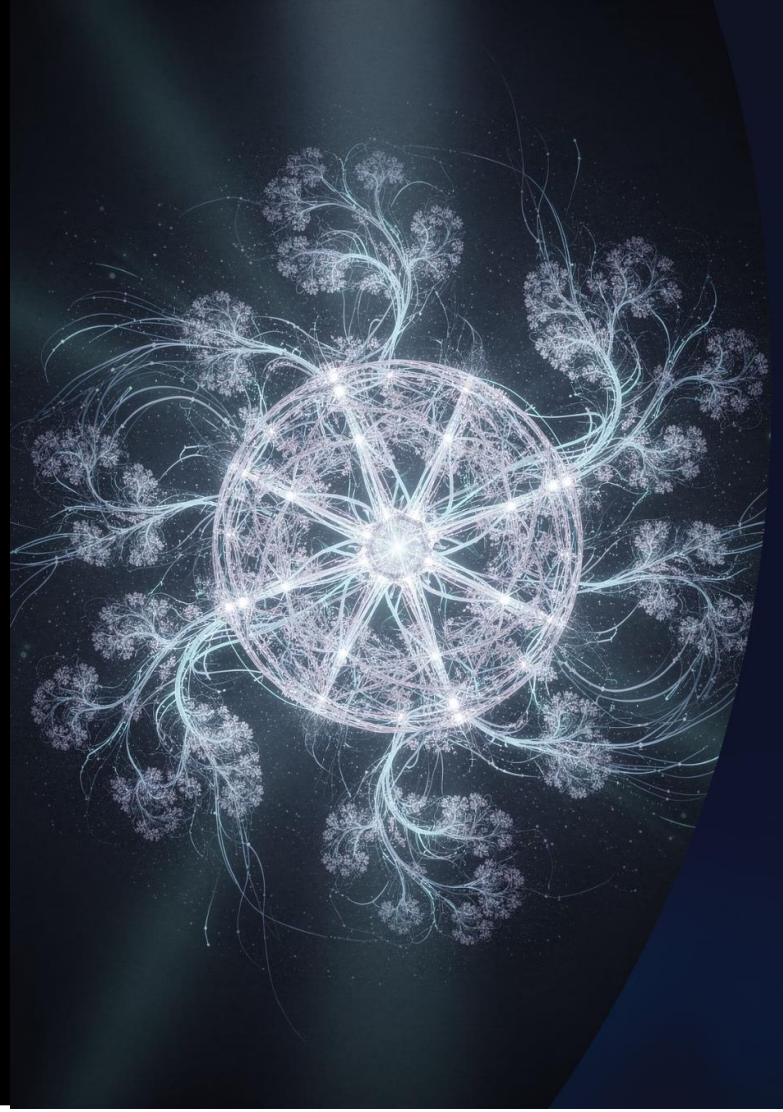
Short Replacement Cycles

Competitive pressure accelerates hardware obsolescence, shrinking the operational lifespan of data center equipment.

Low Recycling Rates

Fewer than 20% of e-waste materials are formally recycled globally, leaving toxic compounds in landfills and waterways.

AI 4 UNI
UNIVERSITY OF SZCZECIN
UNIVERSIDAD PABLO DE OLAVIDE SEVILLA
OSTİM TECHNICAL UNIVERSITY ANKARA
SGroup UNIVERSITIES IN EUROPE
University of Hradec Králové Faculty of Informatics and Management
Co-funded by the European Union



CHAPTER 2

The Cost of Reasoning and Generative AI

Generative and reasoning AI models represent a qualitative leap in capability — and a corresponding leap in environmental cost. Understanding this new class of impact is essential for any honest sustainability assessment.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

Generative AI: A New Level of Impact

Training at Scale

Generative AI models are trained on datasets measured in petabytes, requiring weeks or months of continuous compute across thousands of specialized accelerators — each training run emitting carbon equivalent to dozens of transatlantic flights.

Reasoning Model Surge

Reasoning models have seen a staggering **320-fold increase** in usage in 2025 compared to 2024. Each "chain-of-thought" inference cycle consumes far more compute than a standard query, multiplying the per-request energy cost dramatically.

Advertising Integration

Image and video generation models are being integrated into digital advertising at an unprecedented pace, embedding high-energy AI inference into billions of daily impressions across global ad networks.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

Digital Waste: The Unstudied Problem

While physical waste is visible and measurable, **digital waste** — data stored without purpose, redundant synthetic content, and idle model weights — represents an emerging sustainability challenge that remains largely unquantified.

Dark Data

Vast quantities of stored data consume server energy and cooling resources without ever being accessed or serving a productive function. Estimates suggest over 50% of enterprise data falls into this category.

Synthetic Data Explosion

Generative AI enables the creation of synthetic data at unprecedented scale. Without governance, this accelerates the accumulation of digital waste, consuming storage and compute resources for content that may never be used.

Intergenerational Impact

The energy and infrastructure commitments made today to support digital waste will persist for decades. The environmental costs of today's data glut will be inherited by future generations.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

The Hidden Cost of Innovation

Every upgrade cycle, every new model iteration, every discarded device contributes to a growing environmental ledger that the AI industry has yet to fully account for. The true cost of innovation must include what we leave behind.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

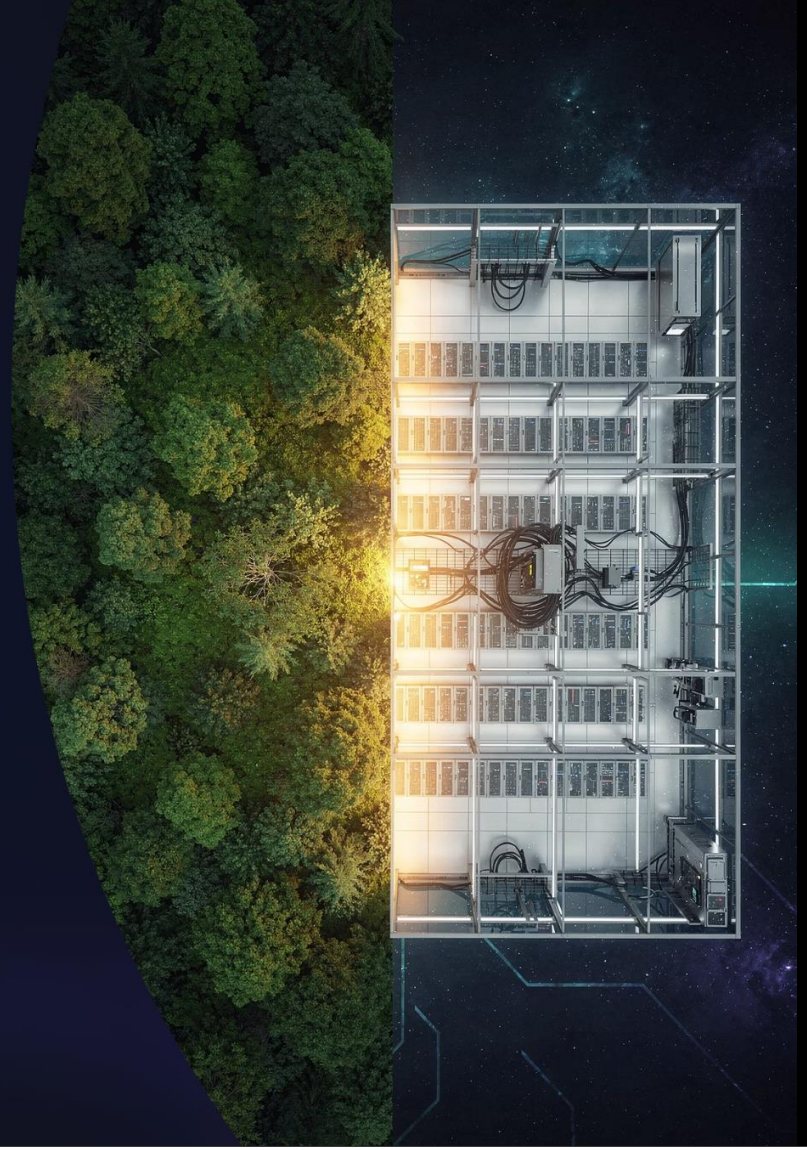
University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

CHAPTER 3

The Imperative for Green AI

Recognizing the problem is only the first step. The imperative for Green AI demands systemic change — in how we measure, report, design, and govern artificial intelligence systems across their entire lifecycle.



Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové
Faculty of Informatics and Management

Co-funded by the European Union

Measuring What Matters: The Need for Transparency

A Transparency Deficit

Even as AI deployment has accelerated dramatically, **transparency about its environmental impacts has declined**. Major AI labs have reduced public reporting on training energy, water usage, and emissions — making independent verification nearly impossible.

Inconsistent measurement practices and fragmented accountability structures obscure the true scale of AI's footprint and prevent meaningful comparison between providers and models.

What Mandatory Transparency Must Cover

- **Inference consumption** — per-query energy use across deployment at scale
- **Compute locations** — grid carbon intensity of data center locations
- **Training benchmarks** — standardized reporting of training energy and emissions
- **Water usage** — cooling water consumption per model and facility

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI
UNIVERSITY OF SZCZECIN
UNIVERSIDAD PABLO DE OLAVIDE SEVILLA
OSTİM TECHNICAL UNIVERSITY ANKARA
SGroup UNIVERSITIES IN EUROPE
University of Hradec Králové Faculty of Informatics and Management
Co-funded by the European Union

The Sustainable AI Quotient (SAIQ)

The **Sustainable AI Quotient (SAIQ)** is an emerging metric framework designed to track how efficiently AI systems transform money, energy, and emissions into measurable performance outcomes — enabling decision-makers to balance financial viability, energy resilience, and environmental impact simultaneously.

Smarter Silicon

Invest in energy-efficient chip architectures — including neuromorphic and analog computing — that deliver more compute per watt.

Cleaner Data Centers

Transition data center power to verified renewable sources and optimize cooling infrastructure for water and energy efficiency.

Strategic AI Use

Deploy AI selectively where it delivers genuine value, avoiding unnecessary inference on low-value tasks that inflate the environmental cost-benefit ratio.

Governance-as-Code

Embed sustainability constraints directly into AI development pipelines — automated checks for energy budgets, model size thresholds, and emissions limits.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

Greenpeace's Call to Action: Limit Negative Impacts

Ecological Risk at the Forefront

Greenpeace has issued urgent calls for the tech industry to confront AI's ecological impact head-on — moving beyond narrow conversations about social risk and bias to address the physical, planetary costs of AI infrastructure.

Their position is clear: **AI must not be allowed to exacerbate the climate crisis**. The energy demanded by AI data centers must be met with clean power, not extensions of fossil fuel infrastructure. Water stressed regions must not bear the burden of cooling AI systems serving global consumers.

Greenpeace advocates for binding commitments, independent audits, and civil society participation in AI governance — ensuring ecological accountability is not left to voluntary corporate disclosures.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové
Faculty of Informatics and Management

Co-funded by the European Union

Balancing Growth with Responsibility

The choice is not between AI progress and environmental protection. It is about designing systems, policies, and behaviors that allow both to coexist — and thrive together.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

CHAPTER 4

User and Developer Responsibility

Systemic change requires individual action. Whether you are an end user, a software developer, or an enterprise decision-maker, the choices you make in how you adopt, build, and consume AI have real and measurable environmental consequences.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

Optimizing AI Use: Responsible Consumption

1

Measure Your Footprint

Proactively request usage data and energy estimates from your AI suppliers. Prioritize vendors who offer transparent, verifiable reporting on inference energy and emissions per query.

2

Question AI's Necessity

Before deploying AI for a task, ask whether a simpler, lower-energy solution would suffice. Not every problem requires a large generative model — apply AI where it genuinely delivers irreplaceable value.

3

Exercise Your Rights

Users have the right to opt out of unnecessary generative AI integration in products and services. Push back on feature bloat that embeds high-energy AI into workflows that do not require it.

4

Advocate Internally

Champion sustainability criteria in AI procurement decisions within your organization, including energy source requirements and efficiency benchmarks for shortlisted providers.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

Greener Coding and Model Choices

Practical Developer Actions

Developers hold significant leverage over AI's environmental impact. The models chosen, the infrastructure selected, and the code written all directly determine the energy consumed at inference time — multiplied across millions of user interactions.

Right-Size Your Models

Choose the **smallest model** that meets your task's performance requirements. Larger is not always better — and the energy difference between a 7B and 70B parameter model is enormous at scale.

Leverage Pre-Trained Models

Utilize fine-tuning and transfer learning from pre-trained models instead of training from scratch. Reusing existing weights eliminates the enormous upfront training energy cost.

Green Coding Practices

Train development teams in **sustainable software engineering** — optimizing loops, reducing redundant computation, and designing inference pipelines for energy efficiency from day one.

Model Selection Checklist

- Does the provider publish energy consumption data?
- Is the data center powered by verified renewables?
- Is there a smaller model variant that meets requirements?
- Can quantization or pruning reduce inference cost?
- Is fine-tuning available instead of full training?
- Does the provider offer carbon-offset API tiers?

Co-funded by the European Union

The Future of AI: A Sustainable Path Forward

AI is a genuinely powerful technology with transformative potential — but **that potential does not come without cost**. Technological advances in chip efficiency and renewable energy are necessary, but they are not sufficient on their own.

1 Acknowledge the Cost

Recognize that AI's environmental footprint is real, large, and growing — and that honest accounting is the foundation of any credible sustainability strategy.

2 Demand Transparency

Push for mandatory, standardized reporting from AI providers on energy, water, and emissions — at the model, inference, and facility level.

3 Build Consciously

Embed sustainability into every phase of AI development — from architecture choices and training infrastructure to deployment decisions and end-of-life hardware planning.

4 Govern Proactively

Embrace Green AI policies that align AI's exponential growth trajectory with international climate commitments, before the environmental debt becomes irreversible.

Erasmus+ Cooperation partnerships in higher education, 2024-1-PL01-KA220-HED-000250324, WP3. Skills and competencies development

AI 4 UNI

UNIVERSITY OF SZCZECIN

UNIVERSIDAD PABLO DE OLAVIDE SEVILLA

OSTİM TECHNICAL UNIVERSITY ANKARA

SGroup UNIVERSITIES IN EUROPE

University of Hradec Králové Faculty of Informatics and Management

Co-funded by the European Union

Your Role in a Sustainable AI Future

The scale of AI's environmental challenge can feel overwhelming — but individual and collective choices matter enormously at this critical juncture.

🌍 Understand

Educate yourself on the real environmental costs behind the AI services you use daily. Awareness is the first form of accountability.

📣 Advocate

Demand transparency from AI providers and policymakers. Support organizations and regulations that hold the tech industry to rigorous, enforceable environmental standards.

⚡ Act

Make conscious, deliberate choices as a user and developer. Minimize unnecessary AI consumption, select greener providers, and champion sustainable practices in every team and organization you are part of.

The future of AI does not have to be a future of environmental compromise. With the right choices — made now, by everyone in this ecosystem — Green AI can become the standard, not the exception.