

# AI

## The Artificial Intelligence/Sustainability Paradox

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SAG Part 3 Basics

# The Paradox We Face

One ChatGPT query uses electricity to light a bulb for 20 minutes (de Vries, 2023).

vs.

AI could reduce global emissions by 5 billion tons annually (BCG, 2024).

## Which number matters more?



# Our Journey Today

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## Act I: What Is

The Growing Environmental and Social Cost of AI

## Act II: What Could Be

AI as Societal Solution Catalyst

## Act III: New Bliss

Navigating the Paradox Responsibly

# Act I: What Is

The Growing Societal Costs of AI  
Energy • Carbon • Resources • Society

# AI's Energy Reality

## Current State (2025)

**Data Centers** 3-4% global electricity

**AI Workloads** 10-15% of data center energy

**Growth Rate** 30% Compound Annual Growth Rate (CAGR) through 2030

**2030 Projection** 415 → 945 TWh

By 2030: AI = Argentina's entire electricity consumption

# The Cost of Intelligence

## Training Energy Consumption

<b>Model</b>	<b>Energy</b>	<b>CO<sub>2</sub> Emissions</b>	<b>Equivalent</b>
<b>GPT-3</b>	1,287 MWh	552 tons	120 cars/year
<b>GPT-4</b>	~51,800 MWh	13,000 tons	2,800 cars/year
<b>BLOOM</b>	433 MWh	50.5 tons	11 cars/year
<b>Llama 3</b>	2,700 MWh	1,090 tons	240 cars/year

GPT-4 training = Annual consumption of 13,000-17,000 EU households

# Every Query Counts

## Inference at Scale

### Daily Reality:

- Google Search: 0.3 Wh
- ChatGPT Query: 2-3 Wh (**10x increase**)
- ChatGPT Daily: 564 MWh (200M users)

### Water Cost per Conversation:

- 20-50 questions = 500ml water
- 300M weekly users = swimming pool daily

**Hidden Multiplier:** Each response generates 3-5x more

# Corporate Carbon Reality

## Emissions Growth Despite Pledges

Company	Emissions Change	Cause
<b>Google</b>	+48% since 2019	14.3M tons total
<b>Microsoft</b>	+29% since 2020	"AI acceleration"
<b>Meta</b>	+66% since 2019	Data center expansion

"The exponential growth in AI is straining our net-zero commitments" (Microsoft, 2024)

# The Water Crisis Nobody Discusses

## AI's Hidden Thirst

### Training Requirements:

- GPT-3: **700,000 liters** cooling water
- Microsoft Azure: **6.4 million m<sup>3</sup>** annually (+34% YoY)
- Google: **6.1 billion gallons** in 2023

### Geographic Conflict:

- **160+ data centers** in water-stressed regions
- Arizona, Singapore, Northern Virginia hotspots
- Competition with agriculture and communities

**Per Query:** 16.9ml water evaporated

# Hardware's Dark Side

## The Physical Foundation

### Critical Materials:

- **17 rare earth elements** per GPU
- **80% supply** from China
- **<1% recycling rate** for AI hardware

### E-Waste Trajectory:

- 2025: 54 million tons globally
- 2030: 1.2-5M tons from AI alone
- GPU replacement: every 1-3 years

### Mining Impact:

- Dysprosium, Terbium, Cobalt extraction
- Child labor in mining, (e.g. proven cases in Cobalt mines Democratic Republic of the Congo)
- Water pollution in rare earth processing

# The Rebound Effect in AI

## Why Efficiency Gains Fail

### Historical Pattern:

- Steam engines: 100x efficiency → 1000x coal use
- Cars: 30% fuel efficiency → 50% more driving

### AI's Paradox (2017-2023):

- **44x efficiency improvement** per query
- **100x increase** in total AI workloads
- **Net result:** 2x total energy consumption

**The Trap:** Lower costs → More use cases → Higher total impact

# The Social Cost of AI

## Digital Inequality Deepens

### Global AI Divide:

- **90% of AI researchers**  
in 10 countries
- **2.6 billion people**  
remain offline
- **72% of data centers**  
in high-income nations

### Labor Disruption:

- **47% of jobs**  
at high automation risk
- **450,000**  
fossil fuel workers displaced
- **87% lack**  
re-training access

### Environmental & Social Injustice:

- Data centers in  
**65% minority communities**  
(USA)
- **70% e-waste**  
exported to Global South
- Low-income pay  
**3x more**  
per kWh for AI services

# Act II: What Could Be

AI as Solution Catalyst

Modeling • Energy • Agriculture • Innovation

# Climate Modeling Revolution

## From Months to Hours

### **Speed Transformation:**

- Traditional: 90 days for 1000-year simulation
- AI-Enhanced: **12 hours**
- Impact: Test 100x more scenarios in the same time

### **Breakthrough Applications:**

- Hurricane paths: 85% accuracy at 7 days
- Regional downscaling: 10km → 1km resolution
- Tipping point detection: advance prediction with scenarios

**Estimated Market Growth:** €266M (2024) → €1.2B (2029)

# Smart Grid Transformation

## Real Impact at Scale

### Deployment Reality:

- **74% of utilities** using AI (2024)
- **20% error reduction** in demand forecasting
- **15% peak load** reduction

### Case Studies:

- DeepMind + UK Grid: **10% efficiency gain**
- Duke Energy + AWS: **30% outage reduction**
- Austria Verbund AG: **18% efficiency gain**

### Renewable Integration:

- Wind prediction: **20% value improvement**
- Solar forecasting: **92% accuracy**
- Battery optimization: **40% lifetime extension**

# Agricultural Revolution

## Beyond Yield Optimization

### **Water & Chemical Reduction:**

- Irrigation: **40% water savings** (Israel)
- Pesticides: **97% reduction** potential (ecoRobotix)
- Fertilizer: **30% reduction** with same yield

### **Real Deployments:**

- John Deere: 300,000 connected machines
- Full Nature Farms: Serving 40% of US tomatoes
- India: 7 million farmers on AI advisory

**Food Waste:** AI reduces 20% of 1.3B tons annual waste

# Transportation & Logistics

## Immediate Carbon Wins

### Google's Fleet Management Impact (2024):

- Fuel-efficient routing: **2.7M tons CO<sub>2</sub>** saved
- Green Light (traffic): **30% fewer stops**
- Contrails reduction: **54% with American Airlines**

### Logistics Optimization:

- UPS: **100,000 tons CO<sub>2</sub>/year**
- DHL: **15% fuel reduction**
- Maersk: **20% empty container reduction**

**Urban Impact:** 700+ cities already using AI traffic management

# Material Science Breakthroughs

## Accelerating Green Innovation

### Discovery Speed:

- Traditional: 10-20 years per material
- AI-Assisted: **Weeks to months**

### Recent Breakthroughs:

- DeepMind GNoME: **2.2M new crystals** (45x previous knowledge)
- Microsoft + PNNL: New battery in **80 hours**
- MIT: Concrete that stores energy

### Carbon Capture Materials:

- 1000+ new MOFs identified
- 10x improvement in CO<sub>2</sub> absorption
- Cost reduction: 70% projected

# Biodiversity & Conservation

## AI as Nature's Guardian

### **Wildlife Protection:**

- WWF Kenya: **96% reduction** in elephant poaching
- Rainforest Connection: Illegal logging down **70%**
- Ocean monitoring: 75% of illegal fishing detected

### **Species Discovery:**

- BioCLIP: **300+ new species** identified
- iNaturalist: 150M observations, 400K species
- eBird: 1 billion bird observations analyzed

### **Ecosystem Monitoring:**

- Amazon: Daily deforestation alerts
- Coral reefs: Bleaching prediction 2 weeks advance
- Migration patterns: Climate adaptation tracking

# The Net Impact Equation

## Quantifying the Balance

Potential by 2035:

### **Application Area Annual CO<sub>2</sub> Reduction**

Energy Systems 1.2 GtCO<sub>2</sub>

Transportation 0.8 GtCO<sub>2</sub>

Manufacturing 0.6 GtCO<sub>2</sub>

Buildings 1.0 GtCO<sub>2</sub>

Agriculture 0.4-1.4 GtCO<sub>2</sub>

**Total Potential 4.0-5.0 GtCO<sub>2</sub>**

**\*\*AI's Own Footprint:\*\*** 0.4-1.6 GtCO<sub>2</sub>

Net Benefit: 2.4-4.6 GtCO<sub>2</sub> (3-8x positive)

# Act III: New Bliss

Navigating the Paradox Responsibly  
Solutions • Governance • Future Pathways

# Technical Solutions Today

## Efficiency Without Rebound

### Architecture Innovation:

- Model pruning: **90% size reduction**
- Quantization: **75% memory savings**
- Knowledge distillation: **96% inference energy cut**
- DeepSeek R1: Outperforms at **1/10th size**

### Hardware Evolution:

- TPUs: **80% less energy** than GPUs
- Neuromorphic chips: **100x efficiency**
- Optical computing: **1000x potential**

**Edge Computing:** 60% reduction in transmission energy

# Green Infrastructure

## Available Now, Underdeployed

### Cooling Revolution:

- Liquid cooling: **40% energy reduction**
- Stockholm: Heats **25,000 homes** with waste heat
- Free cooling: **65% of year** in Austria

### Renewable Integration:

- Google: **64% carbon-free** energy
- Microsoft: **100% renewable** by 2025
- **12 GW** clean energy PPAs contracted

### Location Matters:

- Iceland: 100% renewable, natural cooling
- Austria: 78% renewable grid advantage

# Circular AI Economy

## From Linear to Regenerative

### **Linear Model (Current):**

Extract → Manufacture → Use (2-3 years) → Dispose

### **Circular Model (Achievable):**

Design for longevity → Modular upgrades → Reuse → Refurbish → Recycle

### **Impact Potential:**

- **70% material reduction**
- **7-10 year** hardware lifecycle
- **90% recovery rate** possible
- **60% cost savings** long-term

# EU Regulatory Framework

## From Voluntary to Mandatory

### **Corporate Sustainability Reporting Directive (CSRD):**

- **50,000 companies** affected
- Scope 3 emissions (includes AI services)
- First reports: 2026 for 2025 data

### **EU AI Act Environmental Provisions:**

- High-risk AI: Mandatory impact assessment
- Energy consumption disclosure required
- A-G efficiency rating system

### **Digital Product Passport (2027):**

- Full lifecycle tracking
- 90% recyclability target
- Right to repair provisions

# The Doughnut Perspective

## Safe and Just Operating Space

### **Ecological Ceiling - AI Impact:**

- Climate: **0.5-1%** of global emissions
- Freshwater: **0.2%** of consumption
- Chemical pollution: **5% annual growth** in e-waste

### **Social Foundation - AI Contribution:**

- Energy access: **200M people** via optimization
- Education: **500M students** with AI tutors
- Health: **1.2B served** without doctors

**Current Status:** Pushing BOTH boundaries simultaneously

**Alternative Path:** Selective deployment for maximum social benefit within ecological limits

# Just Transition Imperatives

## Who Wins, Who Loses?

### Current Winners:

- Tech companies: **€2.3T market cap** increase
- Skilled workers: **45% wage premium**
- Early adopters: **30% productivity gains**

### Current Losers:

- Displaced workers: **2.3M in routine jobs**
- Global South: **78% of e-waste** burden
- Future generations: Degraded systems inherited

### Transition Finance Needed:

- Reskilling: **€450B globally**
- Infrastructure: **€1.2T** for sustainable data centers
- Compensation: **€230B** for affected communities

# Three Pathways Forward

## The Choice to Make

### **Path 1: Business-as-Usual**

- 2% global emissions by 2030
- Deepening inequality
- Ecological overshoot

### **Path 2: Efficiency-First**

- Carbon neutral with offsets
- Rebound effects unchecked
- Social dimensions ignored

### **Path 3: Sufficiency & Justice**

- Selective AI deployment
- Net negative emissions possible
- Within Doughnut boundaries

# Your Role as Responsible AI Professionals

## Five Principles for Action

### **1. Question Necessity**

"Do we need AI for this?" before "How can AI do this?"

### **2. Design for Longevity**

Build systems that last 10 years, not 2

### **3. Measure Full Impact**

Carbon + Water + Materials + Social costs

### **4. Ensure Fair Distribution**

Benefits to those who bear the costs

### **5. Challenge Power Structures**

Democratic governance of AI deployment

# Resolving the Paradox

"Green AI isn't about choosing between innovation and sustainability. It's about ensuring every joule we invest in intelligence returns dividends in planetary health."