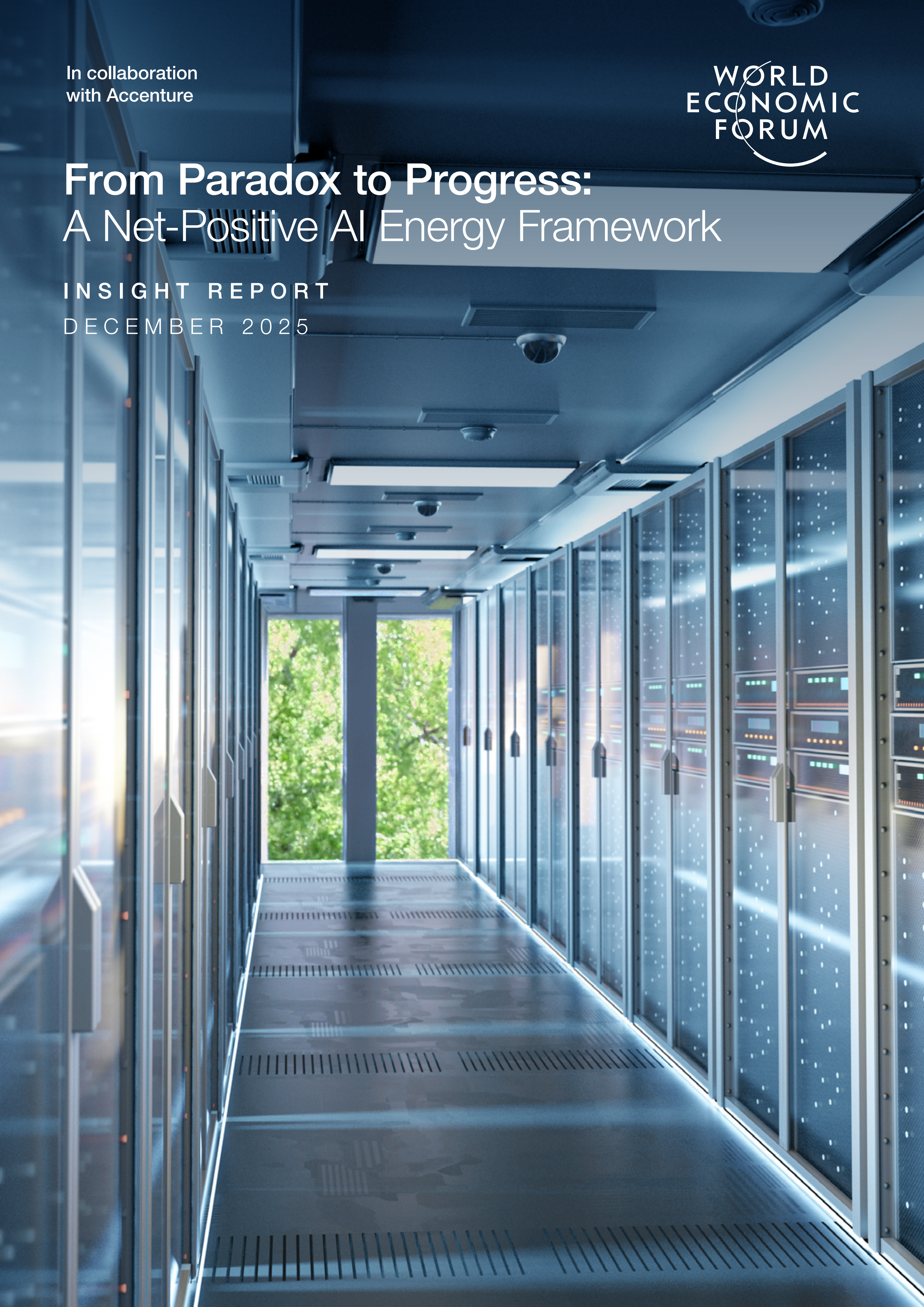
In collaboration with Accenture

From Paradox to Progress:
A Net-Positive AI Energy Framework

INSIGHT REPORT

DECEMBER 2025



Images: Adobe Stock

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Reading guide

The World Economic Forum's AI Energy Impact initiative aims to advance more efficient AI adoption, minimizing energy use while maximizing AI's contribution to a greener, more affordable and secure energy future.

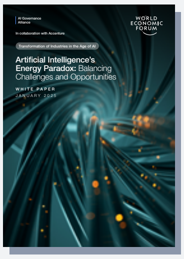
This report series examines AI's transformative energy impact globally, offering insights through both broad analysis and focused regional deep dives. As AI continues to rapidly evolve, each paper in this series aims to provide a snapshot of its energy impact and the landscape at that time.

The series aims to deepen understanding of AI's energy implications through ongoing collaboration with Forum partners and stakeholders shaping AI strategy and implementation. Together, these papers provide both a current and forward-looking view of AI's role in transforming energy systems, and form part of the *Industries in the Intelligent Age* cross-industry series exploring AI's global impact.

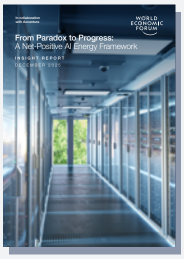
The series includes:

Cross industry

Impact on industrial ecosystems



Artificial Intelligence's Energy Paradox: Balancing Challenges and Opportunities



From Paradox to Progress: A Net-Positive AI Energy Framework

Regional specific

Impact on regions

Upcoming: *Piloting the Future: Azerbaijan's AI-Energy Use Case to Business Case Playbook*

Upcoming: *A Matter of Power: Optimization of AI and Hyperscale Data Centre Infrastructure in MENA*

In January 2025, the Forum, in collaboration with its AI and Energy Impact community and Accenture, published the first paper in the series, [Artificial Intelligence's Energy Paradox: Balancing Challenges and Opportunities](). That paper catalysed a global conversation around AI's dual nature, its potential to accelerate decarbonization and its rapidly rising energy demands. The report called for urgent attention to AI's energy implications and laid the groundwork for a new approach.

This insight report builds upon that foundation and proposes a strategic shift, from paradox to progress, that enables AI scaling to stay aligned with national and corporate energy-transition pathways. It introduces a practical framework for achieving net-positive AI energy: a future in which the energy and resource savings enabled by AI exceed the energy consumed throughout its life cycle.[1] This is not a theoretical ambition. It is a strategic imperative for ensuring AI contributes to, rather than compromises, the resilience, sustainability and equity of energy systems.

Foreword

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Artificial intelligence (AI) is rapidly transforming economies and societies. However, extracting measurable value from AI remains a hurdle. Around 74% of companies still struggle to achieve and scale AI value. Surfaced AI energy use cases show that by embedding sustainability, businesses can unlock measurable value from AI, such as faster deployment and efficiency savings.[2]

From optimizing supply chains and accelerating scientific discovery to enabling smarter infrastructure and more efficient energy systems, AI is becoming a foundational technology for economic competitiveness, energy security and innovation. Yet, as its capabilities grow, so too does its energy footprint, raising the question: can AI drive sustainability and resilience without straining energy systems?

The stakes are high. Without intentional design and governance, AI-driven electricity demand could offset some of the gains made through the deployment of renewable energy and increase operational pressure on generation and transmission systems. Left unchecked, AI could become a hidden contributor to system stress, infrastructure bottlenecks, energy-market volatility and negative climate impacts,[3] all of which could undermine economic competitiveness and system reliability efforts. However, harnessing the latest innovations and with the right levers in place, AI can reinforce, rather than burden, energy systems, enhancing reliability, optimizing grids and other energy assets, reducing emissions and enabling smarter, more efficient decision-making.

AI's expansion is inevitable. The challenge now is ensuring that its growth remains aligned with the capacity and sustainability of its supporting systems.

This paper offers a blueprint for impact-first AI that embeds energy efficiency, responsible deployment and demand-side governance into AI development and use. It draws on real-world insights from a global network of organizations across industry, government, academia and civil society.

Developed by the World Economic Forum's AI Energy Impact initiative, in collaboration with Accenture and leading experts, this framework is a call to action and a guide for coordinated progress. It reflects a growing consensus: aligning AI with energy and sustainability goals is not just a moral responsibility; it is a strategic advantage for economic competitiveness, energy security and inclusive prosperity.

Today's choices will shape the role AI plays in our energy future. A net-positive approach, by design, can ensure that AI becomes a catalyst for energy security, equitable progress and the energy transition.

Executive summary

Achieving a net-positive AI energy outcome demands intentional stakeholder alignment on AI's growth with energy efficiency, resilience and sustainability.

Artificial intelligence (AI) is reshaping industries, unlocking new efficiencies and accelerating innovation. Yet, its rapid growth brings rising energy demands that risk straining infrastructure, undermining competitiveness and offsetting climate gains. In some regions, rising data centre demand has contributed to higher electricity prices for households and businesses, underscoring the importance of aligning AI growth with affordability and public acceptance. By 2035, global data centre electricity use could exceed 1,200 terawatt-hours (TWh), up from 420 TWh in 2024.[4] Without strategic intervention, AI could become a hidden contributor to system stress and climate risk.

Managing AI's energy impact is no longer a future concern – it is a present tense innovation imperative. Net-positive AI energy means ensuring that the energy and resource savings enabled by AI outweigh its life cycle consumption – turning responsible scaling into a source of competitiveness and resilience. While AI can optimize energy use across sectors, its growth must align with system capacity and sustainability goals. The question is not whether AI will grow, but whether it will do so responsibly and in step with the energy transition.

The net-positive AI framework is built around three action drivers:

- Design for efficiency
- Deploy for impact
- Shape demand wisely

These are supported by three strategic enablers:

- Consumer education and workforce upskilling
- Ecosystem collaboration
- Transparent measurement and accountability

Together, they form a coherent blueprint for aligning AI's growth with energy, economic and climate goals. The framework draws on over 130 real-world use cases from more than 15 countries, showcasing how organizations are already realizing benefits such as cost savings, grid reliability and carbon dioxide (CO_2) reductions.

The stakes are high. Transformer shortages, delaying power connections[5] and infrastructure bottlenecks are emerging across regions.[6,7] Without intentional design and governance, AI could deepen digital divides and concentrate capacity in energy-rich regions, leaving others behind.

Yet, the opportunity is clear. AI can significantly reduce data centre cooling energy use,[8] improve heating, ventilation and air conditioning (HVAC) efficiency,[9,10] and optimize grids, logistics and industrial processes.[11,12,13] Companies that embed efficiency into AI design are seeing measurable gains in performance, resilience and sustainability.

This report offers a strategic blueprint for executives, policy-makers and technology leaders to scale AI responsibly. By aligning business goals with sustainable energy outcomes, organizations can accelerate progress towards net-positive AI energy, turning responsible design into a source of lasting competitive advantage.

1

The net-positive AI energy imperative

Building a net-positive AI energy ecosystem ensures that AI strengthens, rather than strains, energy security, competitiveness and climate progress.

> “Net-positive AI energy” refers to a future in which the energy and resource savings enabled by AI exceed the energy and resources consumed throughout the AI system life cycle.

What it is: defining net-positive AI energy

“Net-positive AI energy” refers to a future in which the energy and resource savings enabled by AI exceed the energy and resources consumed throughout the AI system life cycle. The concept encompasses not only energy and resource savings but also broader system-level benefits, including improved energy security, enhanced grid reliability, optimized capacity and reduced operational costs,[14] which are all essential to a resilient and sustainable energy future.

Achieving this outcome requires recognizing the broader AI and energy nexus, the interconnection between AI’s demand for electricity, water, land and critical minerals, and the ecosystems that sustain them. While this paper acknowledges these intertwined resource impacts, its primary focus is on the energy dimension and how AI can be scaled in ways that strengthen energy security, competitiveness and sustainability. Expanding data centres increases energy consumption and emissions, and intensifies water demand for cooling; mineral extraction impacts land and biodiversity. Addressing these cascading pressures through holistic, resource-conscious design ensures that AI’s growth delivers net benefits for the economy, environment and society alike.

Why it matters: the scale of the challenge

To meet AI’s accelerating demand, recent estimates suggest more than $2 trillion in data centre projects are already planned or under construction globally over the next decade.[15] The infrastructure required to power and connect these facilities is expanding at a similar pace. In the US alone, utilities are expected to invest $1.1 trillion over the next five years in new generation and grid capacity, primarily to serve data centres and growing AI workloads.[16] This capital infusion will drive a historic infrastructure build-out, reshaping global power demand, grid planning and investment priorities.

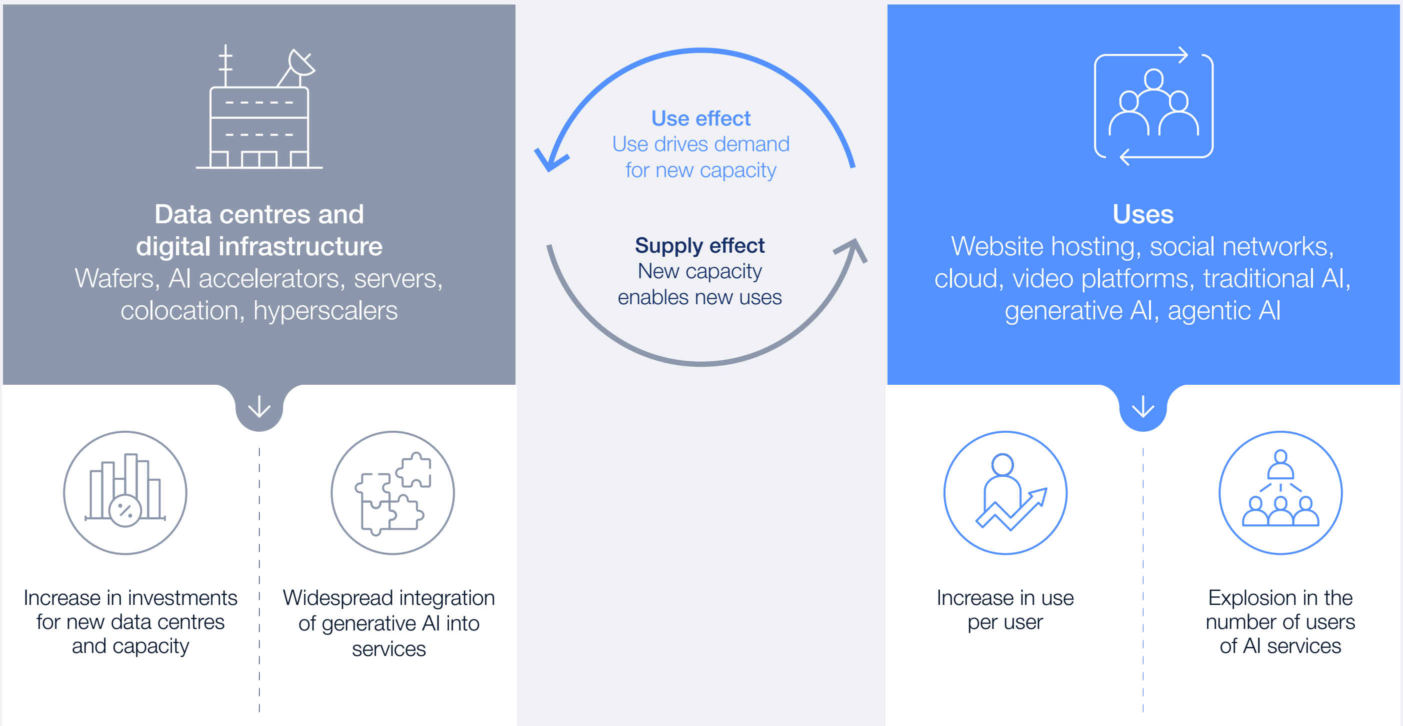
This growth could start to offset annual renewable energy gains,[17] while disrupting national energy planning and straining grids. In many regions, building new renewable, nuclear and grid capacity quickly enough to meet AI-driven demand is not feasible, meaning part of this expansion may still rely on fossil fuels. Even if supply expands, infrastructure upgrades may lag, potentially constraining energy availability and hindering AI growth.[18] A net-positive approach must therefore address not only emissions, but also how clean energy is allocated to ensure AI supports, rather than competes with, broader decarbonization efforts.

Understanding the hidden drivers of AI’s energy footprint

While several forces shape AI’s rising energy use, two main (but not exclusive) drivers are:

1. **The Jevons paradox**: As AI becomes more accessible and its use expands, a key challenge will be ensuring efficiency gains create real value rather than triggering even more AI use that cancels out the energy and resource savings.[19]

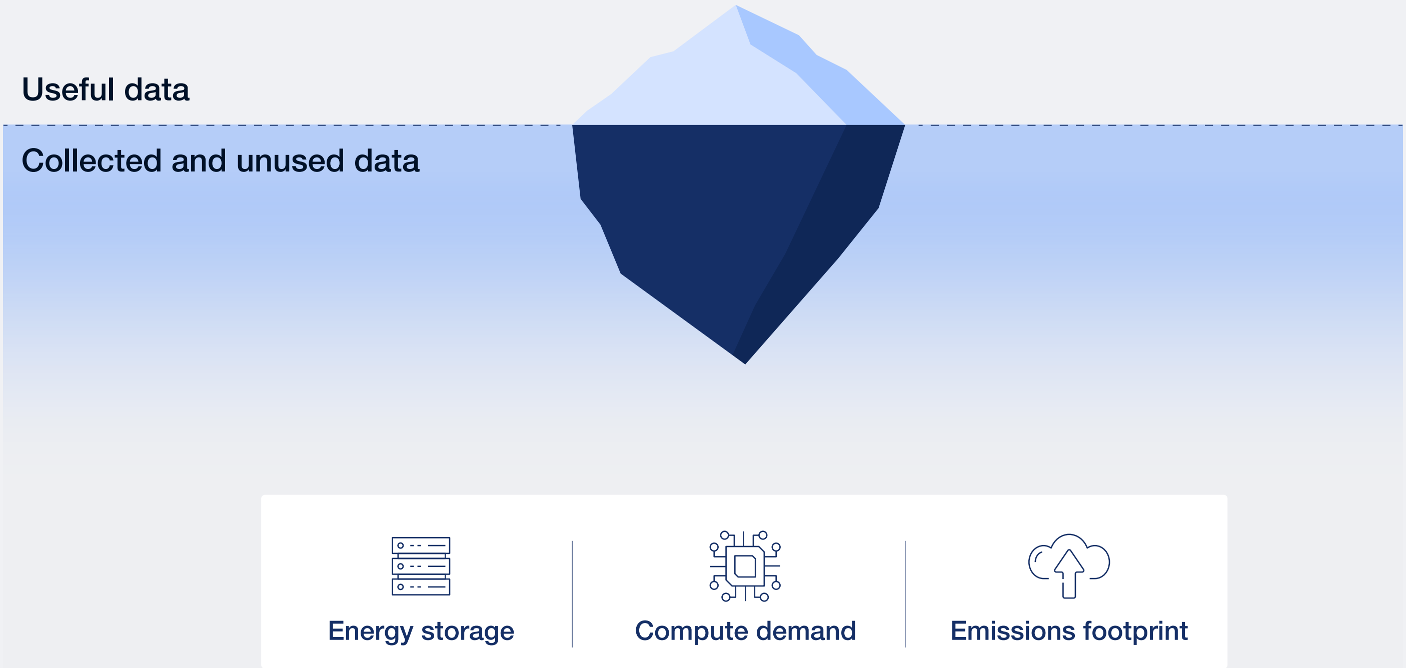
FIGURE 1 **AI data centres’ energy and climate implications**



Source: The Shift Project. (2025). *Intelligence artificielle, données, calculs: quelles infrastructures dans un monde décarboné?* https://theshiftproject.org/app/uploads/2025/09/Synthese-RF-PIA-1.pdf.

② **Dark data and unconscious consumption**: Many AI queries and training runs occur without visibility into their energy or carbon cost, creating wasteful computation and growing volumes of "dark data" that consume power through ongoing storage and cooling.[20]

FIGURE 2 **AI's hidden data impact**



Unlike past digital shifts, today's AI boom is unfolding under explicit resource constraints, presenting a responsibility and opportunity to design energy use deliberately.

The compute demands of frontier models and the concentration of energy use in hyperscale data centres intensify these dynamics. Unlike past digital shifts, today's AI boom is unfolding under explicit resource constraints, presenting a responsibility and opportunity to design energy use deliberately.

The risk of a net-positive divide

The risk of a generative AI divide is a real concern. Countries with concentrated technology capabilities and large-scale data centres are pulling ahead, while others face structural barriers. This imbalance could deepen economic and innovation gaps, creating a two-speed world where AI-driven benefits are unevenly shared. Existing publications and articles[21] show that computing power for advanced AI is increasingly concentrated in a few regions, raising concerns about equitable participation in the AI economy.

Actions to avoid this could include:

- Investing in south-north collaboration and shared infrastructure
- Supporting regional innovation hubs tailored to local energy contexts
- Ensuring equitable access to sustainable computing to prevent digital inequality

As energy becomes a limiting factor, AI capacity may concentrate in regions or firms with surplus electricity and infrastructure. This dynamic risks deepening digital divides and creating asymmetries in access to innovation, potentially turning energy-rich areas into dominant hubs and leaving others behind.[22]

Barriers to achieving net-positive AI energy

Achieving net-positive AI energy requires overcoming a complex set of challenges across six dimensions:

Technical

- Energy-intensive model training and deployment
- Cooling and infrastructure inefficiencies
- Supply-constrained hardware limitations and slow refresh cycles

Measurement and transparency

- Lack of standardized energy use metrics
- Opaque or incomplete energy reporting
- Fragmented data and benchmarking gaps

Behavioural and demand side

- Unconscious consumption and rebound effects
- Elastic demand from low marginal costs
- Limited incentives for energy-efficient behaviour

Regulatory and policy

- Inconsistent regional policy frameworks
- Slow policy adaptation to AI
- Limited uptake of voluntary energy codes and standards

Workforce and capacity

- Skills gaps in AI-energy domains
- Limited education on efficient AI
- Uneven regional readiness

Ecosystem fragmentation

- Siloed innovation and interoperability gaps (technical, regulatory, etc.)
- Misaligned incentives between stakeholders
- Low trust hindering collaboration

Addressing these challenges will require collaboration, investment and accountability across relevant market sectors.

The opportunity: AI as an energy and climate asset

Despite these challenges, AI holds immense potential to accelerate the clean energy transition while also driving competitiveness. Deployed responsibly, AI can enable many benefits, including:

- Reducing data centre cooling energy use by 40%[23]
- Improving commercial building heating, ventilation and air conditioning (HVAC) energy efficiency by 15–40%[24,25]
- Shortening convoluted permitting processes[26]
- Optimizing grid operations, reducing losses and improving reliability[27]
- Enhancing forecasting for renewable energy integration[28]
- Streamlining logistics and industrial processes to cut emissions[29]

The opportunity is clear: if deployed with intention, AI can deliver net-positive energy and climate outcomes, where the benefits outweigh its energy consumption.

Why a new framework is needed

The current trajectory of AI development is largely growth-focused, emphasizing scale, speed and capability.[30] This approach is no longer sufficient.[31] According to industry stakeholders, ecosystem actors must instead shift to an impact-first paradigm that prioritizes measurable outcomes over raw performance.

This framework does not call for constraint, but rather for strategic alignment, ensuring AI's rapid growth advances innovation, supports sustainability and reinforces long-term resilience.

Who is this framework for?

Achieving net-positive AI energy demands collective action. This framework helps stakeholders ensure AI's energy impact becomes a strategic advantage, not a liability.

Those with mature AI systems are applying them to sustainability outcomes at multiple times the rate of others and with a stronger emphasis on long-term value creation.[32] Building this level of capability across industries and regions is crucial to achieving net-positive energy outcomes at scale.

“The opportunity is clear: if deployed with intention, AI can deliver net-positive energy and climate outcomes, where the benefits outweigh its energy consumption.

FIGURE 3 | **Stakeholders in AI's energy impact**

Together, these stakeholders can ensure AI's growth strengthens, rather than strains, global energy and climate systems.

Technology providers

Developers, chipmakers and platform architects shape AI's energy footprint through design, training, hardware, infrastructure and transparency choices.

KEY ACTIONS

- Deploying energy-efficient AI systems and hardware
- Providing user-facing energy transparency tools
- Publishing sustainability benchmarks and life cycle disclosures

Industry leaders

AI can help companies reduce energy use and emissions, driving innovation through clear market signals.

KEY ACTIONS

- Integrating AI into decarbonization and energy efficiency strategies
- Developing phased energy and grid-integration pathways
- Training teams in responsible, energy-aware AI use

Governments and regulators

Policies, incentives and infrastructure planning determine whether AI becomes a climate asset or a liability.

KEY ACTIONS

- Establishing efficiency standards with siting and policy guardrails
- Mandating life cycle energy and emissions reporting
- Supporting shared infrastructure and innovation hubs

Academia and civil society

Academic and civil society organizations develop methods, oversight and training to strengthen measurement, workforce readiness and inclusion.

KEY ACTIONS

- Researching AI consumption metrics and methods
- Developing AI-energy literacy curriculum
- Advocating for transparency and accountability

Consumers and end users

User choices and expectations shape AI's energy impact, markets and policy.

KEY ACTIONS

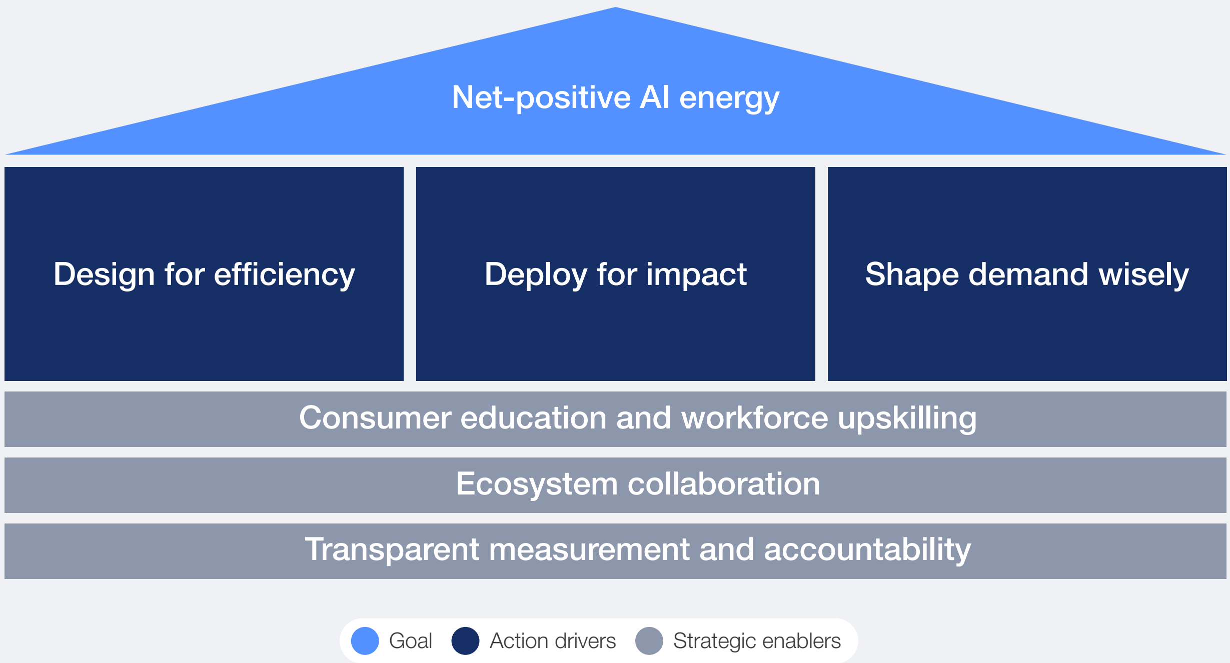
- Choosing energy-efficient AI tools
- Supporting transparent platforms
- Practicing digital sobriety and responsible use

2 The net-positive AI energy framework

To achieve net-positive AI energy, organizations must design efficiently, deploy for tangible impact and shape demand with intent.

To move from paradox to progress, this paper introduces a practical framework built around three action drivers that directly drive measurable energy impact: design for efficiency, deploy for impact and shape demand wisely. These are supported by three strategic enablers, which outline the foundational conditions that make those drivers effective: consumer education and workforce upskilling, ecosystem collaboration, and transparent measurement and accountability. Together, they form a blueprint for aligning AI's growth with energy, climate and economic goals.

FIGURE 4 **The net-positive AI energy framework**



Mapping the AI energy value chain

Although perspectives differ on the exact stages of the AI energy value chain,[33,34,35] they generally include three core components that illustrate where and how AI connects with the broader energy system:

TABLE 1 **The AI energy value chain**

Stage	Description	Relevant action drivers
Upstream inputs	Raw materials, chips, servers, data centres	Design for efficiency
Life cycle operations	Model training, deployment, storage	Design for efficiency, shape demand wisely
Downstream applications	AI-enabled energy savings in grids, buildings, industry, etc.	Deploy for impact, shape demand wisely

Each action driver maps to specific value chain stages, enabling targeted interventions. All strategic enablers span the value chain, providing the measurement, collaboration and education needed to drive progress from infrastructure to applications.

2.1 Design for efficiency

> Data centre electricity consumption is set to more than double to around 945 terawatt-hours (TWh) by 2030… rising to around 1,200TWh by 2035 (base case).
>
> ↗ International Energy Agency (IEA). (2025). *Energy and AI*.

The first action driver, "design for efficiency", embeds sustainability into AI models, hardware and infrastructure from the start.

Making AI itself more efficient

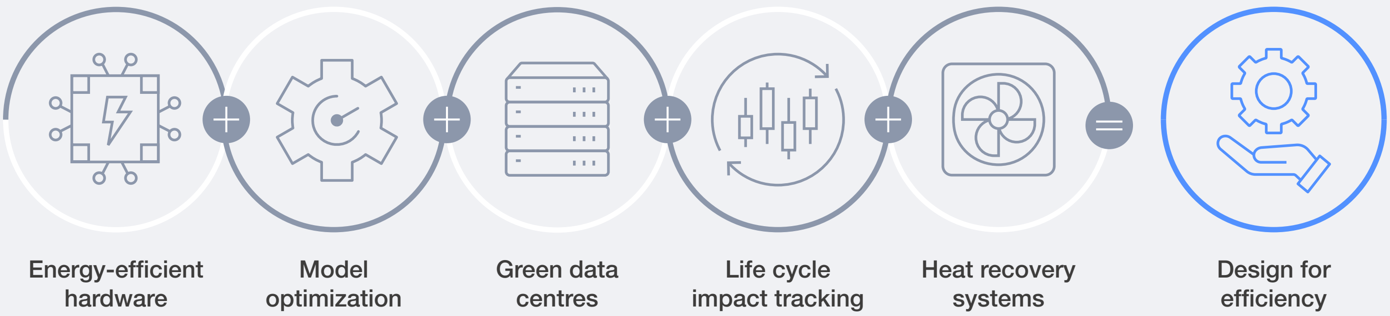
The first action driver, "design for efficiency", embeds sustainability into AI models, hardware and infrastructure from the start. It supports both large-scale systems and smaller, frugal AI[36] approaches by improving efficiency across algorithms, hardware use and system design, enabling models to achieve their purpose with minimal energy and material use. Learn more in the Forum's insight report, *Nature Positive: Role of the Technology Sector*.

Efficiency must also reflect how energy is consumed. Training is brief but power-intensive, while widespread inference can exceed it over time. These patterns vary across AI types and determine where optimization yields the most impact. Since AI requires significant electricity, water, land and materials, building efficiency early enables sustainable growth. This, in turn, ultimately supports this paper's third action driver, shaping demand wisely, by promoting the use of appropriately scaled models for each application.

Key levers include:

- Energy-efficient hardware (low-power chips, accelerators, neuromorphic processors)
- Model optimization (sparse models, quantization, pruning, federated learning)
- Green data centres (renewable-powered, optimized water cooling, modular design)
- Life cycle impact tracking (carbon, water, materials)
- Heat recovery systems (waste heat reuse)

FIGURE 5 **Design for efficiency – key levers**



Use case insights and takeaways:

Across 37% of use cases within the current (but expanding) inventory, organizations are applying diverse levers to improve AI efficiency. However, few measure or disclose life cycle impacts consistently. Progress remains uneven, and transparency is essential.

Strategic recommendations:

- Embed energy key performance indicators (KPIs) into AI procurement and design.
- Align hardware refresh and innovation with sustainability goals.
- Track energy and carbon intensity throughout the AI life cycle.

TABLE 2 Emerging design for efficiency use case examples

Energy-efficient hardware	**Google (AI chips over two generations):** More efficient tensor processing unit (TPU) chip design has led to a threefold improvement in the carbon-efficiency of AI workloads
Model optimization	**Global software company (CodeGen 2.5 Optimization):** Re-engineered architecture and TPU tuning cut training energy 40% with no performance loss, through improved model design and hardware tuning
Green data centres	**Crusoe and Redwood Materials (renewable powered modular AI):** Data centre with second-life electric vehicle (EV) battery storage, anticipating carbon dioxide (CO_2) and operational cost savings
Life cycle impact tracking	**Brussels Environment:** Redesigned digital services with life cycle principles, cutting webpage carbon intensity by approximately 80% and demonstrating efficiency gains through sustainable design
Heat recovery systems	**Nordic District:** Repurposed compute waste heat for heating, supplying 40% of the district's needs

Source: AI Energy Impact public use case database.

BOX 1 The supercomputer: a sovereign, green AI data centre for regulated sectors

Applied

Partially applied

Not applied

Note: This key applies across all boxes.

Challenge

AI growth in regulated sectors is outpacing the available computing power. Building sovereign-grade, high-performance infrastructure remains complex and limited, constraining access to responsible and energy-efficient computing power.

Solution

- Modular, high-performance AI data centres with advanced infrastructure management and liquid cooling
- 3D modelling of thermal and electrical flows for predictive optimization and scalability
- Operating on renewable energy to ensure long-term efficiency and low-carbon performance

Impact

Near-term impacts realized or anticipated (less than one year)

- 50% faster deployment compared to traditional builds
- High computational efficiency
- 20% energy savings

Further impacts realized or anticipated (more than one year)

- Additional efficiency and carbon reductions from ongoing optimization
- Scalable, low-carbon design supporting the expansion of AI infrastructure

Reviewing the levers in action

- (Applied) **Energy-efficient hardware:** Advanced liquid-cooled racks
- (Applied) **Green data centres:** Modular, renewable-powered
- (Partially applied) **Model optimization:** Opportunity to build on infrastructure-driven energy reductions through software efficiency improvements*
- (Partially applied) **Life cycle impact tracking:** Opportunity to integrate real-time life cycle assessment (LCA) to reduce embodied carbon*
- (Partially applied) **Heat recovery systems:** Opportunity to deploy to offset local heating demand*

*See Table 2 for relevant "design for efficiency" use case examples.

Sources: Kahil, H., et. Al. (2025). *Reinforcement learning for data center energy efficiency optimization: A systematic literature review and research roadmap*. Applied Energy, Vol 389, 125734. https://www.sciencedirect.com/science/article/pii/S0306261925004647?; Makin, Y., Maliakkal, R. (2025). *Sustainable AI Training via Hardware-Software Co-Design on NVIDIA, AMD, and Emerging GPU Architectures.* Cornell University. https://arxiv.org/abs/2508.13163?; Lescuyer, L. (2024). *Revealing full data center environmental faces thanks to life cycle analysis.* https://www.datacenterdynamics.com/en/opinions/revealing-full-data-center-environmental-faces-thanks-to-life-cycle-analysis/?; IRENA. (2025). *Waste heat recovery from data centres*. https://www.irena.org/Innovation-landscape-for-smart-electrification/Power-to-heat-and-cooling/31-Waste-heat-recovery-from-data-centres?.

BOX 2 | **Data4All: AI-ready infrastructure for smarter energy systems**

Challenge

Decision-makers lack reliable, accessible, high-quality data. Scarce structured datasets and inconsistent methodologies limit transparency, credibility and evidence-based policy across sectors.

Solution

– Aggregates and standardizes data from over 100 sources to enhance reliability and accessibility

– Provides interactive dashboards for real-time insights across key sectors, including energy, health and trade

– Plans to integrate machine learning (ML) models for predictive analysis and forward-looking decision support

Impact

Near-term impacts realized or anticipated (less than one year)

– Improved transparency and accessibility of national data across multiple sectors

– Strengthened institutional capacity for evidence-based decision-making

Further impacts realized or anticipated (more than one year)

– Implementation of ML and predictive models for future forecasting

– Expanded data coverage and user adoption across sectors

Reviewing the levers in action

- **Model optimization:** Future ML models improve analytical efficiency
- **Life cycle impact tracking:** Supports better policy and sustainability assessment*
- **Energy-efficient hardware:** Dependent on future compute architecture*
- **Green data centres:** Potential alignment via sustainable cloud infrastructure*
- **Heat recovery systems:** N/A

*See Table 2 for relevant "design for efficiency" use case examples.

Sources: AI Energy Impact public database; Domyn; Centre for the Fourth Industrial Revolution Azerbaijan.

Business case

Recent sovereign computing and data infrastructure initiatives show how efficiency-oriented AI can advance both performance and sustainability. Optimized hardware and transparent data governance enable faster, cheaper, and cleaner AI systems, enhancing energy security, competitiveness and sustainability across the data and compute value chain.

2.2 Deploy for impact

The second action driver, "deploy for impact", is where AI drives measurable sustainability gains, advancing efficiency, renewable integration and decarbonization towards net-positive energy.

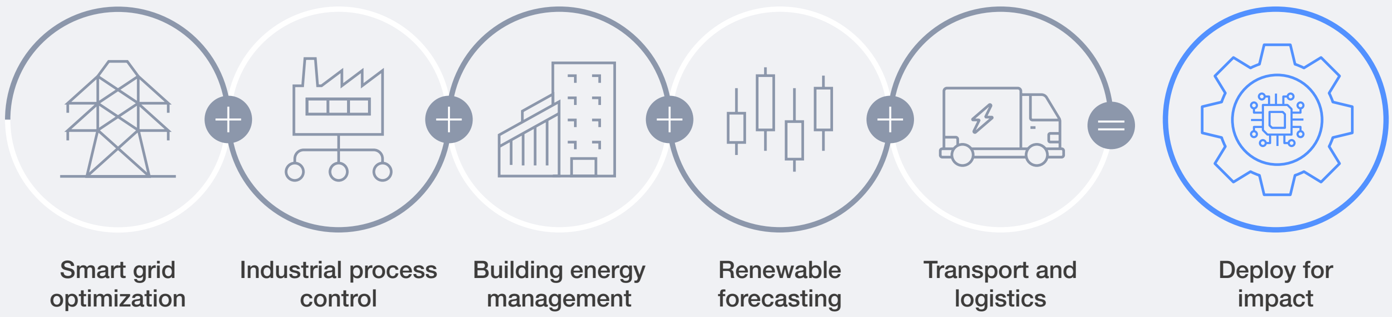
Using AI to reduce energy use across sectors

The second action driver, "deploy for impact", is where AI drives measurable energy system and sustainability gains, renewable integration and decarbonization towards net-positive energy. AI optimizes grids, storage, industry, buildings and logistics to reduce demand, enhance reliability and lower emissions. The task at present is scaling proven solutions beyond pilots. With electrification accelerating, the challenge is not feasibility but the large-scale deployment of AI as a structural enabler of sustainable energy.

Key levers include:

- **Smart grid optimization:** Real-time dispatch, outage prediction, load balancing, unlocked capacity
- **Industrial process control:** Predictive maintenance, energy optimization
- **Building energy management:** AI-enabled HVAC, lighting, occupancy-based control
- **Renewable forecasting:** Improved solar/wind prediction
- **Transport and logistics:** Route optimization, fleet electrification, modal shift planning

FIGURE 6 **Deploy for impact – key levers**



Use case insights and takeaways:

Around 83% of use cases reflected deploy for impact, the most common driver. They show AI delivering sustainability outcomes, from direct energy savings to system-wide gains, such as better outage prediction, load balancing and cost optimization, that enhance grid resilience.

Strategic recommendations:

- Scale proven solutions through public-private partnerships.
- Integrate AI into national decarbonization strategies.
- Set interoperability standards for high-impact sectors.

TABLE 3 **Emerging deploy for impact use case examples**

Smart grid optimization	**Large European energy utility (AI-enabled grid optimization):** Applied AI across 30 million customers, reducing losses, improving reliability and cutting network energy waste
Industrial process control	**Siemens (Chengdu smart factory):** Tailored AI for process control cut electricity use by 24% and waste by 48%
Building energy management	**Japan (smart city pilots):** Coordinated AI for transport, lighting and building control reduced urban energy use by 35%
Renewable forecasting	**Chile (solar plant optimization):** AI integration improved renewable output 15%, reducing curtailment and enhancing grid reliability **Hitachi Energy (intelligent price forecasting):** Energy price forecasting was made 20% more accurate with AI tools
Transport and logistics	**Global retailer (fleet route optimization):** AI-enabled logistics optimized fleet routing, eliminating 30 million unnecessary miles driven, lowering fuel use and supply-chain emissions

Source: AI Energy Impact public use case database.

BOX 3 **AIoT-enabled industrial decarbonization**

Challenge

Ordos, a heavily industrialized region in China long reliant on coal, aimed to transition towards net-zero operations. Challenges included managing renewable intermittency, maintaining energy stability, and achieving carbon visibility and compliance.

Solution

- Deployed an artificial intelligence of things (AIoT) platform as the industrial park's digital brain, integrating wind, solar, storage and industrial loads
- Enabled real-time multi-energy forecasting, dispatch and carbon accounting across wind, solar, hydrogen, storage and EVs
- Embedded AI for product-level carbon traceability and life cycle emissions verification
- Established a collaborative ecosystem connecting government, utilities and industry partners to synchronize energy and carbon data

Impact

Near-term impacts realized or anticipated (less than one year)

- 100,000 megawatt-hours (MWh) energy savings
- 5% peak demand reduction
- 80% forecasting accuracy

Further impacts realized or anticipated (more than one year)

- 200,000MWh energy savings
- 10% peak demand reduction
- 1,000,000 tons of carbon dioxide equivalent (CO_2e) avoided

Reviewing the levers in action

- **Smart grid optimization:** Real-time dispatch, forecasting, and grid balancing
- **Industrial process control:** AI-driven efficiency optimization and carbon reduction
- **Building energy management:** Smart systems for monitoring and facility optimization
- **Renewable forecasting:** Enhanced reliability of intermittent wind and solar generation
- **Transport and logistics:** Coordinated fleet charging with renewable supply and park energy loads

BOX 4 | **AI-driven predictive maintenance for reliable low-carbon power**

Challenge

Industrial energy plants face equipment degradation in turbines and boilers, causing unplanned downtime and disrupting low-carbon power generation. Traditional maintenance remains reactive, increasing inefficiency and outage risk.

Solution

- AI-driven predictive maintenance deployed with a UK-based energy company
- Internet of things (IoT) sensor data and anomaly detection models identify "good behaviour" patterns
- Real-time deviation alerts enable early intervention and optimized scheduling

Impact

Near-term impacts realized or anticipated (less than one year)

- Earlier detection of equipment degradation
- More efficient use of maintenance resources

Further impacts realized or anticipated (more than one year)

- £1.3 million in operational cost savings
- £450,000 in parts and labour savings

Reviewing the levers in action

- **Industrial process control:** Predictive maintenance and energy optimization across industrial plants
- **Smart grid optimization:** Indirect benefits through reliability improvements*
- **Building energy management:** Applied in facility management modules*
- **Transport and logistics:** N/A
- **Renewable forecasting:** N/A

*See Table 3 for relevant "deploy for impact" use case examples.

Sources: AI Energy Impact public database submission, Envision; AVEVA.

Business case

AI is lowering energy intensity across operations. Predictive analytics cut downtime, extend asset life and optimize renewables, storage and demand, advancing economic competitiveness, energy security and sustainability across energy-intensive sectors.

2.3 Shape demand wisely

"Shape demand wisely" focuses on how AI use is governed, timed and incentivized to align energy demand with sustainability goals.

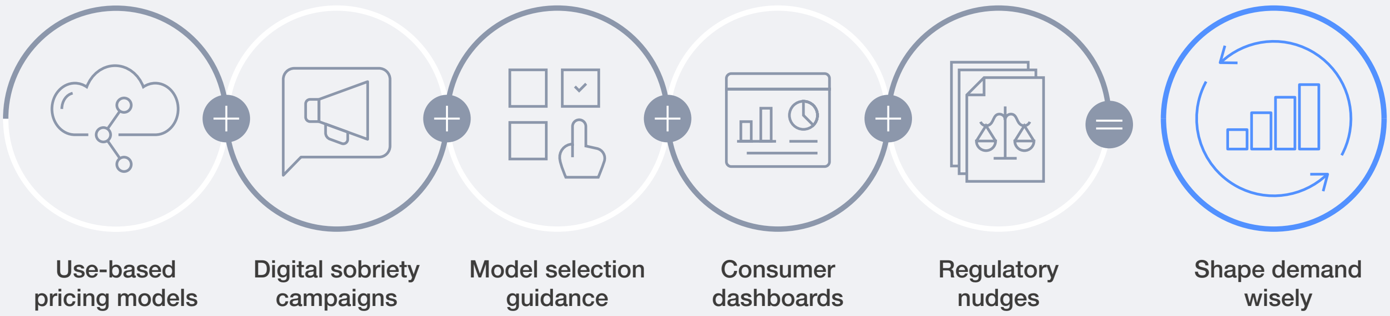
Avoiding unnecessary or unconscious AI use

The third action driver, "shape demand wisely", focuses on how AI use is governed, timed and incentivized to align energy demand with sustainability goals. Building on the design for efficiency driver, it emphasizes proportionate, purpose-driven deployment, using smaller models and adaptive scheduling where possible and reserving large-scale systems for high-value needs. By incentivizing and enabling more flexible and condition-responsive AI consumption, demand can be shaped intelligently rather than simply constrained.

Key levers include:

- **Use-based pricing models:** Price signals and tiered models incentivizing efficiency
- **Digital sobriety campaigns:** Education on query and model energy impacts
- **Model selection guidance:** Promote smaller, fit-for-purpose models
- **Consumer dashboards:** Real-time visibility into energy impact
- **Regulatory nudges:** Efficiency defaults and disclosure standards

FIGURE 7 | **Shape demand wisely – key levers**



Use case insights and takeaways:

Only 10% of use cases reflected shape demand wisely, underscoring a gap or limited visibility into ecosystem activities here. These examples aim to influence AI consumption patterns and promote selective, energy-aware applications. Without greater attention to this driver, efficiency gains risk being offset by continued AI demand growth.

Strategic recommendations:

– Establish AI sustainability labels and energy disclosures.

– Provide public dashboards with opt-in transparency.

– Promote responsible defaults and user awareness.

TABLE 4 | **Emerging shape demand wisely use case examples**

Use-based pricing models	**Cloud provider pilots (tiered pricing):** Ties cost to energy intensity, incentivizing efficient AI use and moderating demand
Digital sobriety campaigns	**Global consulting firm (digital sobriety programme):** This programme drove digital sustainability awareness and audits to cut unnecessary compute and improve energy efficiency
Model selection guidance	**Leboncoin (API traffic optimization):** Detected 3.6 billion redundant API calls weekly, cutting error responses by 72% and server replicas 67%
Consumer dashboards	**Global software company (AI energy score prototype):** A dashboard displayed the energy impact of every query, helping users select lower-energy workflows
Regulatory nudges	**Global media, entertainment and sports company (network efficiency programme):** Regulator partnership optimized network operations, reducing energy use by approximately 40% and meeting efficiency standards

Source: AI Energy Impact public use case database.[37]

BOX 5

AI-powered platform for energy forecasting and dispatch scheduling

Challenge

Rapid renewable growth strains grid reliability in industrial areas. Variable supply and demand make it difficult to achieve consistent, affordable clean energy without accurate short-term forecasting.

Solution

– Cloud platform to optimize energy use and manage distributed energy resources

– AI-enabled forecasting of demand, generation and pricing

– Improved dispatch scheduling, storage management and supply/demand balancing

Impact

Near-term impacts realized or anticipated (less than one year)

– 10–20% renewable utilization improvement

– 90–95% forecasting accuracy

– 95% storage utilization efficiency

Further impacts realized or anticipated (more than one year)

– 5–10% peak demand reduction

Reviewing the levers in action

- **Use-based pricing models:** Enables cost signals through energy-linked performance metrics and benchmarking
- **Consumer dashboards:** Real-time energy visibility and emissions tracking
- **Model selection guidance:** Recommends energy-efficient configurations and workload timing to optimize consumption
- **Digital sobriety campaigns:** Internal initiative, not in scope*
- **Regulatory nudges:** Aligns with ESG frameworks but not policy-driven*

*See Table 4 for relevant "shape demand wisely" use case examples.

BOX 6 | **AI factories as flexible loads for power systems**

Challenge

AI data centres create rising electricity demand and operate as inflexible loads. Without adaptive management, this growth risks grid strain and slower decarbonization. The goal is to make AI infrastructure smarter in how and when it consumes power.

Solution

- Platform enables data centres to optimize power use based on grid conditions
- Predictive models schedule workloads and balance energy demand in real time
- Secure application programming interfaces (APIs) and governance frameworks ensure compliant, responsible operations

Impact

Near-term impacts realized or anticipated (less than one year)

- 40% peak demand reduction
- 1,080 kilowatt-hours (kWh) savings
- 0.68 tons of carbon dioxide emissions avoided per megawatt-hour (tCO_2/MWh)

Further impacts realized or anticipated (more than one year)

- Improved system uptime
- Additional revenues from flexibility services
- Expanded peak demand reduction and carbon emissions avoided

Reviewing the levers in action

- **Usage-based pricing models:** Aligns compute intensity with energy availability, driving efficiency incentives
- **Consumer dashboards:** Real-time visibility into workload timing and energy use
- **Model selection guidance:** Predictive models optimize scheduling and power use
- **Digital sobriety campaigns:** Internal efficiency focus, not public-facing*
- **Regulatory nudges:** Follows National Institute of Standards and Technology (NIST)/ International Organization for Standardization (ISO) standards, not policy-driven*

*See Table 4 for relevant "shape demand wisely" use case examples.

Source: AI Energy Impact public use case database, Infosys; Emerald AI.

Business case

AI demand is shaped through design and governance. Companies embed efficiency into systems, optimize data and model size, and track resource use, while policies and education promote digital sobriety, aligning AI growth with trust and sustainability goals. Smarter demand management also enhances economic competitiveness and energy security, ensuring AI expansion supports system reliability and sustainable growth.

3

Strategic enablers

Education, collaboration and transparency empower the action drivers, turning strategy into measurable, scalable net-positive AI energy outcomes.

These enablers are the connective tissue of the framework, supporting each action driver and enabling scale, trust and coordination.

3.1 Consumer education and workforce upskilling

Consumer education and workforce upskilling equips people and institutions with the knowledge to scale efficient, responsible AI.

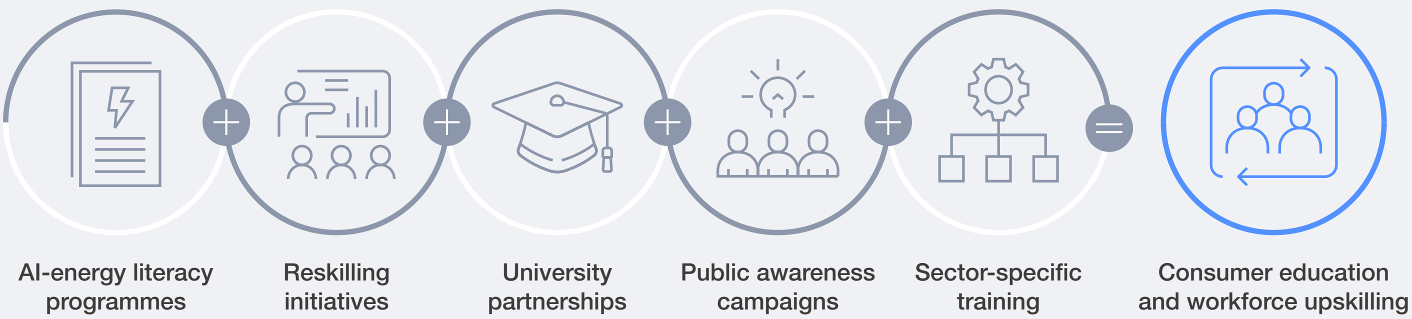
Builds capacity and readiness across sectors

The first strategic enabler, consumer education and workforce upskilling, equips people and institutions with the knowledge to scale efficient, responsible AI. Sustainability depends on informed users and skilled professionals who design and govern systems with a focus on energy and environmental awareness. Training that combines technical and sustainability literacy helps close this gap, while transparent communication about AI's resource impacts empowers responsible use and aligns growth with shared sustainability goals.

Key levers include:

- **AI-energy literacy programmes:** For engineers, policy-makers and business leaders
- **Reskilling initiatives:** Transitioning legacy energy workers to AI-enabled roles
- **University partnerships:** Curriculum development in efficient AI enablement
- **Public awareness campaigns:** Educating consumers on energy-conscious AI use
- **Sector-specific training:** Tailored programmes for manufacturing, utilities, etc.

FIGURE 8 **Consumer education and workforce upskilling key levers**



Use case insights and takeaways:

Only about 21% of use cases reviewed involved this enabler. Relevant instances where human capabilities lag behind technical progress underscore the need for greater training and education.

Strategic recommendations:

- Fund education, scholarships and workforce training
- Partner with universities to develop industry-aligned curricula
- Launch national responsible AI use campaigns

TABLE 5 **Emerging consumer education and workforce upskilling use case examples**

AI energy literacy programmes	**Global energy services provider (AI academy):** Trained energy professionals to use AI for enhanced planning and streamlined operations
Reskilling initiatives	**French Ministry of Culture (systemic design workshops):** Trained digital teams to apply life cycle and sustainability principles in service design
University partnerships	**North American academic consortium:** Integrates life cycle energy assessment and environmental accountability into engineering and design education, advancing interdisciplinary sustainability learning
Public awareness campaigns	**International Energy Agency (IEA) and AI observatory:** Open public platform to raise awareness of AI's energy footprint and efficiency potential, providing shared insights for policy-makers, enterprises and researchers
Sector-specific training	**Raptor Maps (solar workforce programme):** Trained technicians to use AI-enabled digital twins for inspections, reducing data volume 99% and improving fault detection

Source: AI Energy Impact public use case database.

BOX 7 **ADEME national campaign for responsible digital consumption**

Challenge

Rising digital energy demand has outpaced public understanding of its environmental impact. Many organizations lack frameworks to evaluate or reduce the energy footprint of digital operations.

Solution

- Public awareness and education campaign promoting responsible digital consumption
- Digital sobriety guidelines, training materials, and policy recommendations to integrate sustainability into IT and AI practices
- Workshops for businesses, schools, and public institutions to build literacy in sustainable digital behaviour

Impact

Near-term impacts realized or anticipated (less than one year)

- Nationwide engagement in digital sobriety education and awareness
- Early adoption of eco-design practices

Further impacts realized or anticipated (more than one year)

- Broader integration of digital sobriety guidelines
- Increased visibility of AI and digital energy impacts

Reviewing the levers in action

- ✓ **AI energy literacy programmes:** Builds understanding of digital energy use among policy-makers and professionals
- ✓ **Public awareness campaigns:** Reaches broad audiences through national engagement and communication.
- ✓ **University partnerships:** Provides open educational resources for academic use*
- ✓ **Reskilling initiatives:** Encourages future workforce development in sustainable IT*
- ✓ **Sector-specific training:** Applies general guidance to industry settings*

*See Table 5 for relevant "consumer education and workforce upskilling" use case examples.

BOX 8 | AI forecasting for more efficient industrial processes

Challenge

Industrial operations often rely on siloed data and manual monitoring, limiting real-time optimization and increasing emissions and operational costs

Solution

- 20 predictive models deployed across energy park processes
- Real-time forecasting integrated with centralized plant control
- AI platform and modular architecture support scaling and integration

Impact

Near-term impacts realized or anticipated (less than one year)

- 24% productivity increase
- €5.1 million realized savings in one year
- Full plant adoption with over 30 active users

Further impacts realized or anticipated (more than one year)

- Projected €60–80 million annual impact across multiple sites
- Additional energy savings and avoided emissions
- Replication across other facilities

Reviewing the levers in action

- **AI energy literacy programmes:** Training to interpret AI-driven insights for operational efficiency
- **Reskilling initiatives:** Workforce transition from manual to AI-assisted operations
- **Sector-specific training:** Customized training modules for operations and industrial energy management
- **University partnerships:** Insights shared with technical institutions through applied projects. Academic chair in partnership with San Pablo CEU (Madrid) focused on green digital. Partnership with Alcalá de Henares University (Madrid), centred in IoT technologies
- **Public awareness campaigns** – N/A

Source: ADEME. (2025). *Soyons malins, reprenons la main: notre campagne pour un numérique plus responsable*. https://altimpact.fr/soyons-malins-reprenons-la-main-notre-nouvelle-campagne-pour-un-numerique-plus-responsable/; ADEME. (2025). *Numérique: reprendre la main pour des usages responsables*. https://infos.ademe.fr/magazine-janvier-2025/numerique-reprendre-la-main-pour-des-usages-responsables/; AI Energy Impact public use case database, Moeve.

Business case

Building skills for efficient AI requires public and professional action. Education raises awareness of AI's energy impacts, while training equips engineers to drive efficiency and decarbonization, creating the human foundation for responsible adoption.

3.2 Ecosystem collaboration

Ecosystem collaboration and governance aligns public and private sectors, research institutions, and civil society to accelerate responsible, energy-aware AI adoption.

Harmonizing standards, incentives and infrastructure

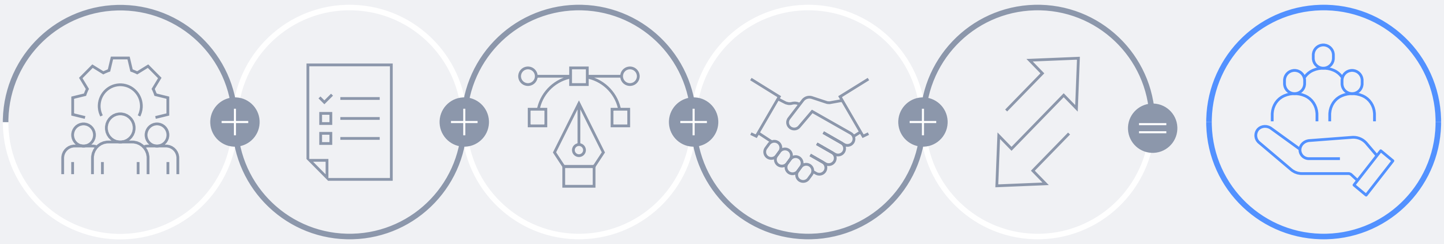
The second strategic enabler, ecosystem collaboration and governance, aligns public and private sectors, research institutions, and civil society to accelerate responsible, energy-aware AI adoption. Collaboration harmonizes efforts, shares risks and scales solutions that no actor can achieve alone, while ensuring equitable access to low-carbon compute and reliable connectivity.

Effective governance depends on shared standards, transparent data exchange and coordinated infrastructure investment. Cross-sector partnerships advance model efficiency, clean-energy integration and digital infrastructure planning while reducing duplication. Industrial clusters illustrate this potential, with AI synchronizing energy flows, waste heat and material exchanges, unlocking greater efficiency, flexibility and circularity across connected industries.[38]

Key levers include:

- **Multistakeholder taskforces:** Industry, academia and government alignment
- **Policy harmonization:** Cross-border standards for AI energy accountability
- **Joint infrastructure planning:** Shared investment in green compute zones
- **Incentive alignment:** Tax credits, grants and procurement preferences
- **Interoperability frameworks:** Common protocols for energy-aware AI systems

FIGURE 9 **Ecosystem collaboration key levers**



Use case insights and takeaways:

Roughly 57% of use cases reviewed emphasized this enabler. Examples ranged from collaborative renewable procurement to shared grid integration platforms, illustrating how pooling resources and aligning governance can accelerate adoption.

Strategic recommendations:

- Facilitate coalition formation through funding and convening platforms
- Align projects with national clean energy strategies
- Promote governance models that balance innovation and equity

TABLE 6 **Emerging ecosystem collaboration use case examples**

Multi-stakeholder taskforces	**Australia (renewable energy project):** A coalition of cities, universities and companies aggregated demand through a joint renewable PPA, securing long-term clean power and supporting grid decarbonization
Policy harmonization	**European Union (policy collaboration):** The European Union introduced voluntary sustainability commitments across member states as a foundation for future AI energy governance standards
Joint infrastructure planning	**Spain (smart port infrastructure programme):** Applied AI to logistics, improving operational efficiency and reducing vessel turnaround time by 30%
Incentive alignment	**Global telecom-utility partnerships:** Joint pilots applied AI to optimize telecom network energy use in coordination with grid conditions, improving efficiency and reducing peak-period demand
Interoperability frameworks	**North American global innovator:** Cross-industry portfolio partnerships standardized scalable HVAC optimization, reducing energy use by 20–30%

Source: AI Energy Impact public use case database.

BOX 9 **Public-private partnerships building responsible AI ecosystems**

Challenge

Fragmented coordination across public institutions, start-ups and industry limits AI's potential for sustainable growth. Without shared frameworks and standards, Europe's AI ecosystem risks uneven development and wasted resources.

Solution

- Cross-sector partnership between technology providers, policy-makers and research institutions
- Europe-wide framework for responsible AI adoption
- Assessment of regulatory readiness, data infrastructure and workforce skills, offering policy and investment guidance
- Results informed regional competitiveness strategies and harmonized sustainability objectives across stakeholders

Impact

Near-term impacts realized or anticipated (less than one year)

- Engagement across 15 countries and 28,000 participants
- Improved visibility into AI adoption, infrastructure gaps and workforce readiness

Further impacts realized or anticipated (more than one year)

- Stronger alignment between governments and enterprises on responsible AI governance
- Enhanced integration of sustainability considerations in national AI roadmaps

Reviewing the levers in action

- ✓ **Multistakeholder task force:** Coordinates AI ecosystem stakeholders
- ✓ **Interoperability frameworks:** Builds shared frameworks for AI governance and sustainability alignment
- ✓ **Joint infrastructure planning:** Connects national AI hubs and innovation clusters
- ✓ **Policy harmonization:** Supports harmonized regulatory discussion but does not define standards independently*
- ✓ **Incentive alignment:** Enables shared insights and funding dialogue, though direct pooled investment remains limited*

Note: *See Table 6 for relevant "ecosystem collaboration" use case examples.

BOX 10 | AI-driven battery grading for scalable, sustainable manufacturing

Challenge

Traditional battery grading tests each cell through full charge-discharge cycles – a slow, energy-intensive process that limits scale, raises costs and hinders sustainable, efficient production.

Solution

- AI-modelled battery capacity prediction using real-world production data
- AI-driven performance learning improving prediction accuracy and reducing manual intervention
- AI-enabled manufacturing optimization increasing throughput and lowering environmental impact

Impact

Near-term impacts realized or anticipated (less than one year)

- 750,000kWh saved per gigawatt-hour (GWh) of production
- 32% faster production cycles
- Less than 1% manual oversight required

Further impacts realized or anticipated (more than one year)

- $7.5 million in annual savings
- 200–300 internal users across multiple sites

Reviewing the levers in action

- **Multistakeholder task force:** Collaborates with stakeholders to advance AI-enabled battery systems
- **Interoperability frameworks:** Joint initiatives with regional governments and energy agencies to scale infrastructure
- **Joint infrastructure planning:** Active participant in technology clusters linking AI, mobility and renewable integration
- **Policy harmonization:** Contributes to battery safety and data-sharing standards*
- **Incentive alignment:** Co-funded demonstration projects; broader financing collaboration remains limited*

*See Table 6 for relevant "ecosystem collaboration" use case examples.

Sources: Amazon Web Services (AWS). (2025). *Unlocking Europe's AI Potential in the Digital Decade 2025*. https://www.unlockingeuropesaipotential.com/; MINDS 2025.

Business case

Cross-sector collaboration drives cost- and energy-efficient AI. Governments, industry and researchers align investment, infrastructure and governance to create shared standards, build trust and advance responsible, sustainable growth.

3.3 Transparent measurement and accountability

Enables visibility, benchmarking and trust

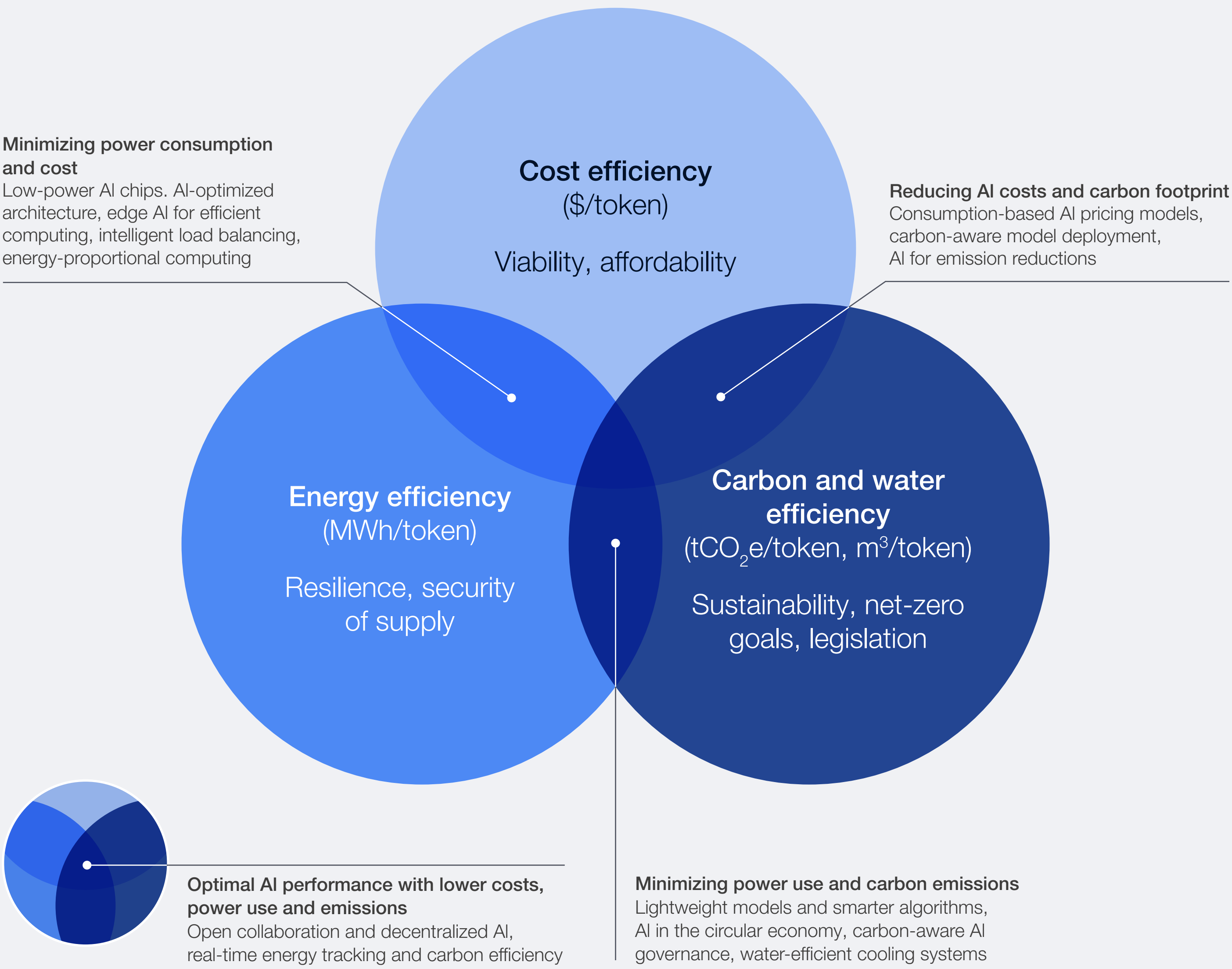
The third strategic enabler, transparent measurement and accountability, establishes consistent metrics to quantify AI's resource use and environmental impact. Without shared standards, progress cannot be tracked or compared, leaving organizations with fragmented insights into efficiency and a limited understanding of how energy use connects to cost, water, materials and land use, as well as emissions.

A multidimensional metric, such as Accenture's Sustainable AI Quotient (SAIQ),[39] demonstrates one possible approach. It measures how effectively AI systems convert financial, energy, carbon and water inputs into useful performance, offering a composite score that supports comparable benchmarking and informs operational and governance decisions for more efficient AI.

FIGURE 10 **Accenture's SAIQ**

$$\text{SAIQ} = w1.\frac{\$}{\text{token}} + w2.\frac{\text{MWh energy}}{\text{token}} + w3.\frac{\text{tCO}_2\text{e}}{\text{token}} + w4.\frac{\text{m}^3\text{ water}}{\text{token}}$$

FIGURE 11 **The SAIQ framework: evaluating AI's cost, energy and environmental footprint across the value chain**

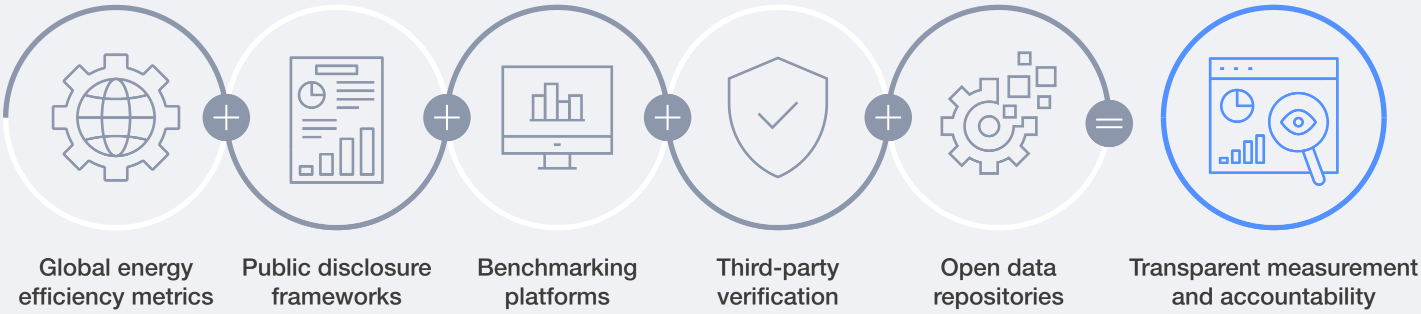


Embedding such measures into reporting and oversight systems enables comparability, accountability and continuous improvement in resource use. In turn, this creates a foundation for transparent, data-led progress towards more efficient AI.

Key levers include:

- **Global energy efficiency metrics**: Joules per inference, life cycle carbon intensity
- **Public disclosure frameworks:** AI energy use ESG reporting standards
- **Benchmarking platforms:** Cross-industry tools for comparing AI workloads
- **Third-party verification:** Independent audits of AI infrastructure and models
- **Open data repositories:** Shared datasets for energy impact research

FIGURE 12 **Transparent measurement and accountability key levers**



Use case insights and takeaways:

A notable 81% of use cases incorporate this enabler. Many rely on dashboards or carbon-tracking systems. However, few extend to standardized reporting or external validation. Establishing global standards and open platforms will be essential to scale impact and build trust.

Strategic recommendations:

- Establish AI energy efficiency and carbon intensity global standards
- Require benchmarking compliance for public procurement
- Support open data platforms and third-party audits

TABLE 7 **Emerging transparent measurement and accountability use case examples**

Global energy efficiency metrics	**North American information technology (IT) firm (automated server decommissioning):** Monitoring identified underused servers with deactivation saving 10,475MWh and 3,506 tonnes of CO_2, demonstrating life cycle energy accounting and efficiency benchmarking
Public disclosure frameworks	**North American and European innovators (transparency and efficiency):** Published model emissions and resource use data; created an AI energy score leaderboard, setting benchmarks for public reporting and accountability
Bench-marking platforms	**ARCEP, France (ICT sustainability benchmark):** Developed a national platform to measure and publish energy and emissions data across digital operators, creating transparent benchmarks for environmental accountability
Third-party verification	**CartoBio, France:** Improved product efficiency through feature retirement and interface redesign, reducing resource use and exemplifying digital sobriety in sustainable software design
Open data repositories	**Global sustainability consortium:** Curates public case studies enabling transparent cross-sector comparison and shared sustainability baselines

Source: AI Energy Impact public use case database.

BOX 11 | **AI model efficiency: transparency on energy and carbon impact**

Challenge

AI model training and inference consume large amounts of energy and water. Comprehensive data on their environmental impact has been limited, making efficiency measurement difficult.

Solution

- Google developed a methodology to measure Gemini inference model energy and water use, and carbon emissions
- Enables users to understand environmental cost of each prompt

Impact

Near-term impacts realized or anticipated (less than one year)

- A 33-fold reduction in energy and a 44-fold reduction in carbon per prompt
- Transparent reporting of model-level environmental impact

Further impacts realized or anticipated (more than one year)

- Offers replicable measurement approach to inform broader sustainability practices
- Supports user awareness and responsible deployment

Reviewing the levers in action

- **Global energy efficiency metrics:** Reports efficiency at the inference and model level, publishing energy-per-query improvements
- **Public disclosure frameworks:** Sustainability reports include AI and data centre ESG energy disclosures
- **Benchmarking platforms:** Contributes research to open benchmarking*
- **Third-party verification:** Limited data centre operations verification, but independent model audits emerging*
- **Open data repositories:** N/A

*See Table 7 for relevant "transparent measurement and accountability" use case examples.

BOX 12 | A low-energy AI system for emotion-aware social media analysis

Challenge

Conventional AI approaches for social media analysis depend on high-compute deep learning models that process data indiscriminately. These systems are energy-intensive, opaque and computationally inefficient.

Solution

- Hybrid AI architecture that integrates rule-based reasoning, supervised ML and natural language processing guided by a bespoke emotion ontology
- A semantic filtering layer that ensures only emotionally relevant content is processed, enabling deployment on ultra-low-power hardware

Impact

Near-term impacts realized or anticipated (less than one year)

- Significant reduction in unnecessary data processing
- Operational on low-energy devices with minimal compute overhead
- Energy savings and avoided carbon emissions

Further impacts realized or anticipated (more than one year)

- Deployment scale and replicability
- Improved storage utilization efficiency
- Enhanced user engagement and improved adoption metrics

Reviewing the levers in action

- **Benchmarking platforms:** Model efficiency and transparency for real-world applications
- **Open data repositories:** Shared datasets and evaluation tools to advance openness and reproducibility in AI-energy impact measurement
- **Global energy efficiency metrics:** Standardized model-level metrics and performance indicators*
- **Public disclosure frameworks:** Research output and methodologies that inform disclosure frameworks*
- **Third-party verification:** Peer-reviewed validation and independent assessment*

*See Table 7 for relevant "transparent measurement and accountability" use case examples.

Sources: Gomes, B. (2025). *Our approach to energy innovation and AI's environmental footprint*. Google. https://blog.google/outreach-initiatives/sustainability/google-ai-energy-efficiency/; AI Energy Impact public database, Loughborough University.

Business case

Transparency enables responsible AI energy use. Shared metrics, open benchmarks and verified disclosures make impacts visible and comparable, building accountability and turning measurement into practical, system-wide trust.

Putting it all together

The net-positive AI energy framework serves not as a checklist, but as a blueprint to align stakeholder action. The three action drivers optimize energy use, while the three strategic enablers create the conditions for scale.

Together, they form a reinforcing system. For example:

- Design for efficiency requires transparent life cycle measurement and skilled teams, supported by consumer education and workforce upskilling and transparent measurement and accountability.
- Deploy for impact needs ecosystem alignment and policy support, enabled by ecosystem collaboration.
- Shape demand wisely benefits from consumer awareness and regulatory nudges, supported by all three enablers.

Deployed together, these drivers and enablers ensure sustainable AI growth and advance a more resilient, efficient and equitable energy future.

Next steps and call to action

The path to achieving net-positive AI energy is clear, but it requires coordinated, cross-sector action. The time to move from insight to implementation is now. Whether a technology provider, manufacturer, utility, policy-maker or academic institution, the following are immediate steps that can be taken:

Short term (0–12 months):

- **Assess your AI energy and material footprint:** Conduct AI system life cycle analyses, including training, deployment, infrastructure and embedded materials.
- **Benchmark and disclose:** Establish transparent reporting standards and contribute to open data repositories.
- **Design for efficiency:** Prioritize energy-efficient hardware, modular data centre design and model optimization.
- **Shape demand wisely:** Educate users, implement pricing models and embed energy-conscious defaults into platforms.
- **Submit your use case:** Strengthen the **Forum's public repository**[40] of best practices showcasing the business case for net-positive AI energy by submitting your use case using the Global AI Energy Impact Industry Use Case Submission Form. While the current inventory provides valuable insight into emerging innovation, it is not yet fully globally representative. Expanding it will enable broader representation, deepen collective understanding, and help accelerate global progress.

Middle term (one to three years):

- **Deploy for impact:** Integrate AI into efficiency strategies across operations, supply chains and infrastructure.
- **Collaborate across sectors:** Join multistakeholder taskforces like the AI Energy Impact initiative, align with regional frameworks, and co-invest in shared infrastructure.
- **Invest in talent and consumer education:** Launch AI energy literacy programmes, reskilling initiatives and university partnerships.

Long term (more than three years):

- **Scale what works:** Replicate high-impact use cases across geographies and sectors leveraging resources like the Forum's upcoming AI Energy Foresight tool.
- **Advance standards and governance:** Support the development of enforceable global AI energy accountability frameworks.[41]
- **Drive innovation:** Invest in next-generation technologies (e.g. neuromorphic computing, quantum AI) that reduce energy intensity.

Final call

AI is a strategic lever for competitiveness, resilience and climate action. Yet, without intentional design, governance and collaboration, its energy footprint could undermine the very progress it enables. Time will tell which trajectory prevails, steady transformation or speculative overshoot, and continued research must guide this balance as the ecosystem evolves.

The current ecosystem marks a critical tipping point for shifting from growth-first to impact-first AI, not as a moral imperative, but as a strategic necessity. Scaling AI systems that are resource-efficient and aligned with energy realities can unlock new pathways to profitability, competitiveness and resilience. Achieving a net-positive AI energy future will not happen by chance; it requires intentional design, deliberate collaboration and purposeful scaling.

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Endnotes

1. World Economic Forum. (2025). *Artificial Intelligence's Energy Paradox: Balancing Challenges and Opportunities.* https://reports.weforum.org/docs/WEF_Artificial_Intelligences_Energy_Paradox_2025.pdf.
2. Boston Consulting Group (BCG). *AI Adoption in 2024: 74% of Companies Struggle to Achieve and Scale Value*. https://www.bcg.com/press/24october2024-ai-adoption-in-2024-74-of-companies-struggle-to-achieve-and-scale-value.
3. Levitt, B. (2024). *AI and energy: The big picture*. S&P Global. https://www.spglobal.com/en/research-insights/special-reports/look-forward/ai-and-energy.
4. International Energy Agency (IEA). (2025). *Energy and AI*. https://iea.blob.core.windows.net/assets/601eaec9-ba91-4623-819b-4ded331ec9e8/EnergyandAI.pdf.
5. Wood Mackenzie. (2025). *Power transformers and distribution transformers will face supply deficits of 30% and 10% in 2025*. https://www.woodmac.com/press-releases/power-transformers-and-distribution-transformers-will-face-supply-deficits-of-30-and-10-in-2025/.
6. Moss, S. (2025). *Crusoe begins construction on second phase of Abilene, Texas data center campus, will add six buildings*. Data Center Dynamics (DCD). https://www.datacenterdynamics.com/en/news/crusoe-begins-construction-on-second-phase-of-abilene-texas-data-center-campus-will-add-six-buildings/.
7. Skidmore, Z. (2025). *Natural gas plant planned for Stargate AI data center campus – report*. Data Center Dynamics (DCD). https://www.datacenterdynamics.com/en/news/natural-gas-plant-planned-for-stargate-ai-data-center-campus-report/.
8. Evans, R. and J. Gao. (2016). *DeepMind AI Reduces Google Data Centre Cooling Bill by 40%*. Google. https://deepmind.google/discover/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-by-40/.
9. Brainbox AI. (2025). *Cammeby's International achieves 15.8% reduction in HVAC energy use and costs*. https://brainboxai.com/en/case-studies/cammebys-achieves-15.8-reduction-in-hvac-energy-use-and-costs.
10. Brainbox AI. (2025). *Multi-residential building reduces electricity consumption by 42% in less than 6 months*. https://brainboxai.com/en/case-studies/multi-residential-building-reduces-electricity-consumption-by-42-in-less-than-6-months.
11. Christyjuliet, B, B. Dinesh Kumar, G. Divya, S. Kaviraj, et al. (2024). AI Based Smart Energy Meter for Data Analytics. *International Journal of Scientific Research & Engineering Trends*, vol. 10, issue 6. https://ijsret.com/wp-content/uploads/2024/11/IJSRET_V10_issue6_617.pdf.
12. Wetselaar, M. (2024). *AI in the Energy Industry*. MOEVE. https://www.moeveglobal.com/en/planet-energy/sustainable-innovation/ai-an-opportunity-in-the-energy-industry.
13. Burnham, K. (2024). *How artificial intelligence is transforming logistics*. Massachusetts Institute of Technology (MIT). https://mitsloan.mit.edu/ideas-made-to-matter/how-artificial-intelligence-transforming-logistics.
14. Majkut, J. and L. Abrahams. (2025). *AI for the Grid: Opportunities, Risks, and Safeguards*. Center for Strategic & International Studies (CSIS). https://www.csis.org/analysis/ai-grid-opportunities-risks-and-safeguards.
15. Brookfield (2025). *Building the Backbone of AI*. https://www.brookfield.com/sites/default/files/documents/Brookfield_Building_the_Backbone_of_AI.pdf.
16. Edison Electric Institute (EEI). (n.d.). *Strengthening America's Energy Infrastructure to Increase Reliability & Lower Costs*. https://www.eei.org/-/media/Project/EEI/Documents/Issues-and-Policy/Finance-And-Tax/IndustryCapexReport.pdf.
17. International Energy Agency (IEA). (2025). *Renewables 2025*. https://iea.blob.core.windows.net/assets/11fa0e66-6309-4fa7-a108-1f29da2707bc/Renewables2025.pdf.
18. Zimmerman, L. (2025). *Confronting the AI/energy conundrum*. MIT Energy Initiative. https://energy.mit.edu/news/confronting-the-ai-energy-conundrum/?utm.
19. Diab, R. (2025). *Jevons Paradox Makes Regulating AI Sustainability Imperative*. Tech Policy Press. https://www.techpolicy.press/jevons-paradox-makes-regulating-ai-sustainability-imperative/.
20. Loughborough Business School. (2024). *Loughborough experts shine a light on the climate change impact of dark data*. https://www.lboro.ac.uk/schools/business-school/digital-decarbonisation/news/climate-change-impact-of-dark-data/.
21. Hawkins, Z. J., V. Lehdonvirta and B. Wu. (2025). *AI Compute Sovereignty: Infrastructure Control Across Territories, Cloud Providers, and Accelerators*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5312977.
22. Makala, B. and T. Bakovic. (2020). *Artificial Intelligence in the Power Sector*. International Finance Corporation (IFC). https://www.ifc.org/content/dam/ifc/doc/mgrt/emcompass-note-81-05-web.pdf.
23. Evans, R. and J. Gao. (2016). *DeepMind AI Reduces Google Data Centre Cooling Bill by 40%*. https://deepmind.google/discover/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-by-40/.
24. Brainbox AI. (2025). *Cammeby's International achieves 15.8% reduction in HVAC energy use and costs*. https://brainboxai.com/en/case-studies/cammebys-achieves-15.8-reduction-in-hvac-energy-use-and-costs.
25. Brainbox AI. (2025). *Multi-residential building reduces electricity consumption by 42% in less than 6 months*. https://brainboxai.com/en/case-studies/multi-residential-building-reduces-electricity-consumption-by-42-in-less-than-6-months.
26. Pacific Northwest National Laboratory (PNNL). (2024). *PermitAI*. https://www.pnnl.gov/projects/permitai.

27. Taseen, M., Y. Wang and E. Ali. (2023). *Integration of Artificial Intelligence for Demand Forecasting and Resource Allocation in Renewable Energy Supply Chains*. Institute of Electrical and Electronics Engineers (IEEE). https://ieeexplore.ieee.org/document/10465757.

28. Ibid.

29. Wetselaar, M. (2024). *AI in the Energy Industry*. MOEVE. https://www.moeveglobal.com/en/planet-energy/sustainable-innovation/ai-an-opportunity-in-the-energy-industry.

30. Banipal, I. S. and S. Mazumder. (2024). *How to make AI sustainable*. Nature India. https://www.nature.com/articles/d44151-024-00024-8.

31. Bhardwak, E., R. Alexander and C. Becker. (2025). *Limits to AI Growth: The Ecological and Social Consequences of Scaling*. https://arxiv.org/abs/2501.17980.

32. Bain & Company. (2024). *The Visionary CEO's Guide to Sustainability 2024*. https://www.bain.com/insights/topics/ceo-sustainability-guide/.

33. Cuofano, G. (2025). *The AI Value Chain. The Business Engineer*. https://businessengineer.ai/p/the-ai-value-chain.

34. Laurentys, P. (2024). *The AI VALUE CHAIN: a comprehensive end-to-end framework*. Medium. https://medium.com/@paulomla/the-ai-value-chain-a-comprehensive-end-to-end-framework-e49f4a10a247.

35. O'Donnell, J. and C. Crownhart. (2025). *We did the math on AI's energy footprint. Here's the story you haven't heard*. MIT Technology Review. https://www.technologyreview.com/2025/05/20/1116327/ai-energy-usage-climate-footprint-big-tech/.

36. Arga, L., F. Bélorgey, A. Braud, R. Carbou, et al. (2025). *Frugal AI: Introduction, Concepts, Development and Open Questions*. HAL. https://hal.science/hal-05049765/file/Frugal_AI_Introduction_Concepts_Development_and_Open_Questions_HAL.pdf.

37. King, C. (2025). *Tracking the Impact of AI: Salesforce's AI Energy Score*. Sustainability Magazine. https://sustainabilitymag.com/articles/tracking-the-impact-of-ai-salesforces-ai-energy-score.

38. World Economic Forum. (2025). *Five Steps for Digital Collaboration in Industrial Clusters*. https://reports.weforum.org/docs/WEF_Five_Steps_for_Digital_Collaboration_in_Industrial_Clusters_2025.pdf.

39. Jamison, S., S. Podder, A. Burden, B. Ghosh, et al. (2025). *Powering sustainable AI*. Accenture. https://www.accenture.com/content/dam/accenture/final/corporate/corporate-initiatives/sustainability/document/Powering-Sustainable-AI.pdf#zoom=40.

40. World Economic Forum. (n.d.). *Global AI Energy Impact Industry Use Case Submission Form*. https://wefglobal.eu.qualtrics.com/jfe/form/SV_e8TwphOLljaOX4O.

41. World Economic Forum. (2025). *Advancing Responsible AI Innovation: A Playbook*. https://www.weforum.org/publications/advancing-responsible-ai-innovation-a-playbook/.

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