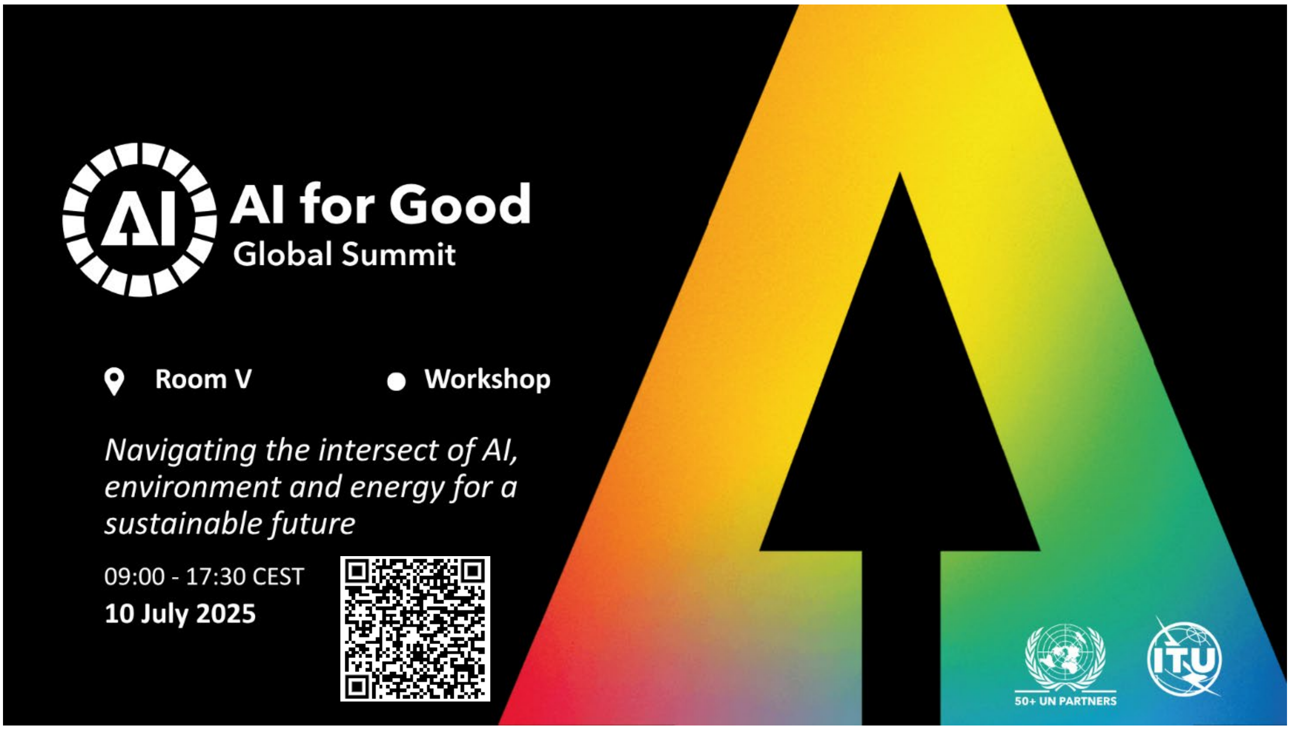
Outcome report



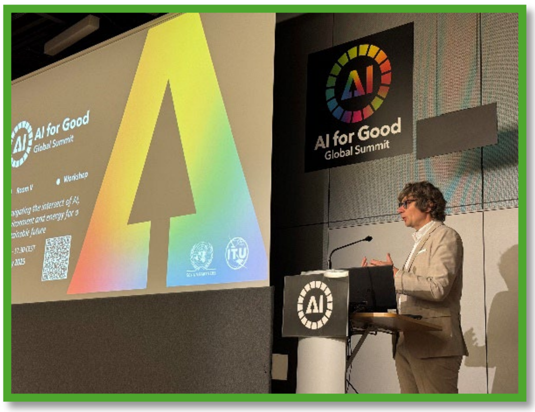
Introduction

In an era in which artificial intelligence (AI) is rapidly reshaping industries, understanding its environmental impact and energy dynamics becomes paramount for steering towards a sustainable future. This multidisciplinary workshop aimed to: unravel the complex relationship between AI, environment and energy consumption; spotlight innovations driving AI environmental efficiency; explore AI's environmental transformative potential in several sectors; and deliberate on the pivotal role of standards, policies and regulations.

This session aligned with ITU's Green Digital Action initiative, reinforcing ITU's commitment to promoting digital innovation, standardization, and global collaboration to foster sustainable AI development while ensuring the ICT sector minimizes its environmental impact and maximizes its transformative potential.

Link to the presentations is here.

The workshop was opened by ITU Deputy Secretary-General, Tomas Lamanauskas. He recalled key figures to set the scene, noting that AI energy consumption has increased by 12 per cent since 2017 and is expected to double, with a projected 150 per cent rise in operational services. He called for the development of sustainable AI.



Gitta Kutyniok (Ludwig Maximilians Universität München, Germany) also delivered opening remarks stressing the importance of addressing sustainability aspects in digital solutions. She emphasized the crucial role of academia and scientific research in advancing environmentally sustainable AI.

Session 1: Understanding AI's environmental impact (0915–1045)

Main discussion

This session provided a comprehensive examination of the environmental footprint of AI systems, emphasizing the resource intensiveness of the AI lifecycle – from data collection and model training to deployment and inference.

The session was moderated by **Sara Ballan (World Bank),** who recalled the physical essence of AI, noting that it requires not only energy but also water and other materials.

- **Francesca Dominici (Harvard University)** presented pioneering research on the environmental impact of hyperscale data centres in the US, and the methodology used to measure carbon emissions. She revealed that 403 such centres are responsible for more than 52 million metric tons of CO_2 annually, representing 1.1 per cent of US electricity-related emissions in 2023. She highlighted the disproportionate effects on marginalized communities, underlining the need for data-driven planning tools that integrate public health and equity concerns. She called for a holistic approach that goes beyond CO_2 emissions to also account for other factors such as air quality
- **Josh Parker (NVIDIA)** emphasized the significant efficiency gains across the AI stack. He noted that large language models (LLM) inference energy efficiency has improved 100 000-fold over the past decade, while liquid cooling systems have reduced water usage by a factor of 300. He acknowledged that AI contributes to electricity load growth but stressed that it still represents a small share (~0.3%) of global electricity use and is increasingly powered by clean energy.
- **Philippe Tuzzolino (Orange/ITU-T SG5 Expert)** stressed the importance of standards and sectoral cooperation to mitigate AI’s environmental and material impacts. He underscored the need for a stable and standardized methodology for measurement and drew attention to ITU initiatives, including:
  - ITU-T L.1472 database and pilot project on ICT sector emissions
  - The draft ITU-T L.EnvAI guideline on AI environmental impact

   - Recent guidelines for Net Zero cities and digital transformation, launched on 8 July 2025

  Rosendo Mañas Faura (Resilio) presented ongoing Swiss-based lifecycle assessments of Mistral AI models, evaluating emissions from both training and inference over a two-year period. The results will help inform standardized environmental impact assessments across countries.

  He also highlighted Recommendation ITU-T L.1450 "Methodologies for the assessment of the environmental impact of the information and communication technology sector", as well as ongoing ITU work on a standard to assess the environmental impact of artificial intelligence systems.

- **Juliette Fropier (French Ministry of Ecology)** discussed France's national strategy for Sustainable AI, emphasizing multistakeholder collaboration, among government, academia and industry, to develop actionable initiatives with international partners. She also highlighted the recently launched Coalition for Sustainable AI.
- **Tim Smolcic (HSBC)** focused on challenges in current AI footprint assessments, noting issues such as:
   - The lack of standardized tools and lifecycle boundaries, which hinders comparability
   - Underreporting of Scope 3 emissions (e.g., hardware, e-waste)
   - Omission of water usage and cooling overheads
   - Over-reliance on estimates rather than observed telemetry data

  He also launched the ITU-GDA report on Measuring What Matters: How to Assess AI's Environmental Impact. This report offers a comprehensive overview of current approaches to evaluating the environmental impacts of AI systems.

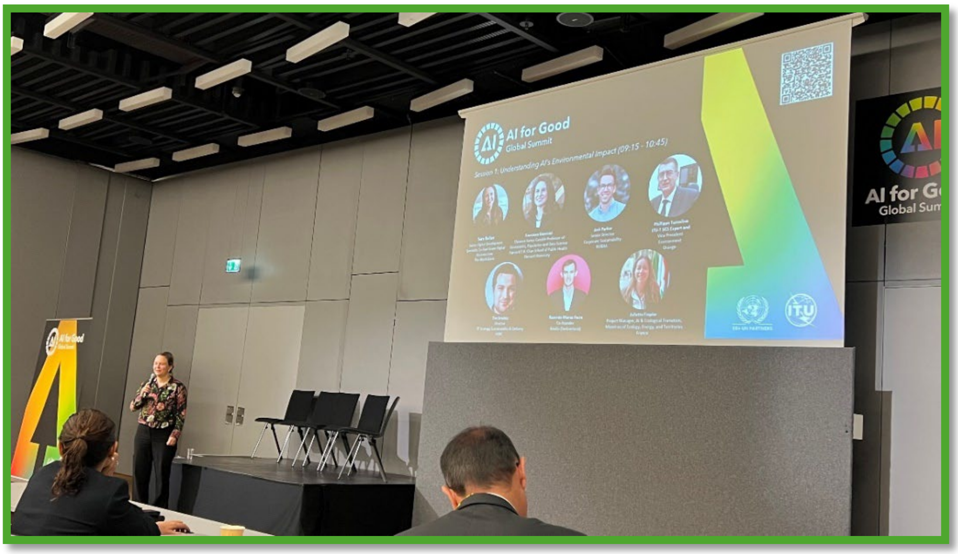
Quotes (adapted from the presentations)

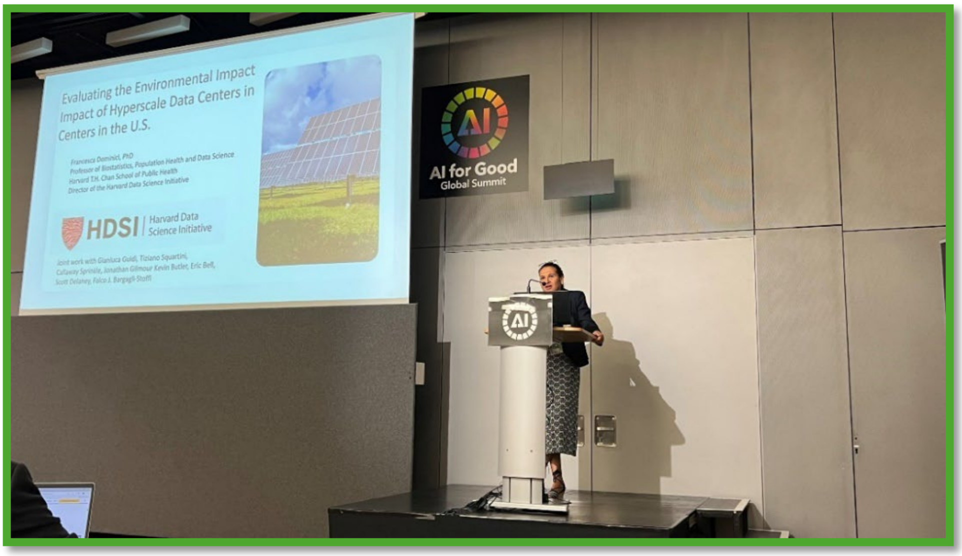
- "We need to move beyond carbon-only metrics and look holistically at water, minerals, and user behavior." — Tim Smolcic
- "The carbon intensity of hyperscale data centers is 52 per cent higher than the U.S. average – we need targeted, location-specific strategies." — Francesca Dominici
-

Key takeaways

- AI's environmental impact is real, complex and growing, not only in terms of energy and emissions, but also with regard to water usage, material intensity and equity considerations.
- Significant progress has been made in efficiency, particularly by industry leaders like NVIDIA, but further efforts are needed to standardize measurements and expand impact assessments to include the full lifecycle and broader ecological factors.
- Several ITU initiatives and standards were highlighted such as:
   - Recommendation ITU-T L.1472 – GHG emissions database for the ICT sector
   - Ongoing work items L.EnvAI (ex L.ClimAI) – Guidelines for AI environmental impact assessment
   - U4SSC reports on Net Zero cities & digital transformation

    - The clear need for harmonized global standards and multiactor cooperation, especially involving regulators, private sector, and UN agencies, to guide AI deployment in alignment with climate goals.
    - Opportunities exist for ITU-T Study Group 5 to advance work on AI-specific standards, particularly in:
        - Model-level environmental accounting
        - Data centre efficiency benchmarking
        - Lifecycle reporting frameworks (including Scope 3)
        - Water use and biodiversity metrics
- The role of regulation was debated, with some speakers advocating for stricter and more accurate regulation, while others questioned its effectiveness, arguing that it may not provide sufficient incentives.



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Measuring what matters: How to assess AI's environmental impact
Artificial Intelligence for Climate Action:
Advancing Mitigation and Adaptation in Developing Countries
Methodology to assess Net Zero progress in cities
Guidelines for cities to achieve carbon Net Zero through digital transformation
50+ UN PARTNERS

Session 2: Innovations in environmentally efficient AI (1115–1245)

Main discussion

This session explored technological innovations aimed at reducing AI's environmental footprint across the hardware-software stack. Panellists shared perspectives on energy-efficient AI models, neuromorphic computing, sustainable data centre operations, and the role of green energy.

The session was moderated by **Ivana Drobjnack (University College London),** who highlighted the daily impact of energy savings and shared her views on a future based on optimizing large models, while using small models when appropriate. She emphasized the importance of designing for efficiency from the outset, presenting scenarios where task-specific small models can achieve over 90 per cent energy savings. She also discussed emerging architectures such as Mixture of Experts, retrieval-augmented generation, neurosymbolic AI, and brain-inspired designs as promising pathways toward sustainability.

- **Gitta Kutyniok (Ludwig Maximilians Universität, München)** opened with a compelling call to rethink AI from the ground up, stating "energy is the most serious and urgent problem in AI today." She stressed that current digital computing architectures pose theoretical and practical limitations for sustainability. Citing new mathematical results, she introduced spiking neural networks and neuromorphic computing as biologically inspired alternatives that drastically reduce energy use while enhancing reliability.
- **Roy Schwartz (Hebrew University of Jerusalem)** advocated for the "Green AI" movement, which emphasizes computational efficiency and transparency. He argued that while large models like PaLM consume massive resources (10 000 servers for 50 days), most environmental impact comes from inference, not from training. Inference operations, often overlooked, account for 80–90 per cent of all AI computation and are run billions of times per day. Schwartz urged the community to report compute budgets and match model complexity to task difficulty, considering LLM is not the solution for every problem
- **Jon Turnbull (Google)** presented Google's end-to-end sustainability strategy, which includes:
    - Model optimization (quantization, pruning, knowledge distillation)
    - Custom hardware (e.g., Ironwood TPU, 30x more efficient than its 2018 predecessor)
    - Energy-efficient data centres (6x more compute power than 5 years ago)
    - A target for 24/7 carbon-free energy (CFE) by 2030, through partnerships with geothermal and SMR developers
    - Water replenishment goals and AI-driven cooling optimization (e.g., DeepMind's 40% reduction in cooling energy)

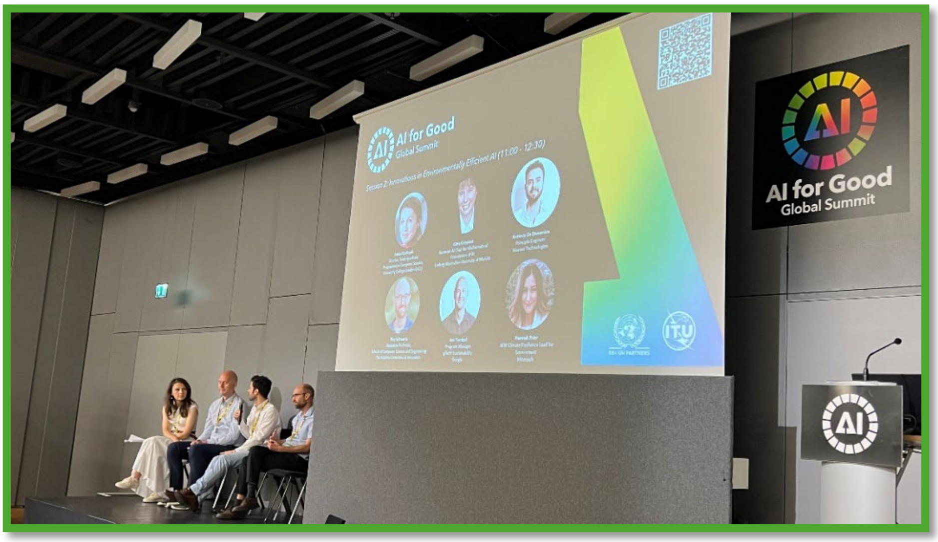
Quotes (adapted from the presentations)

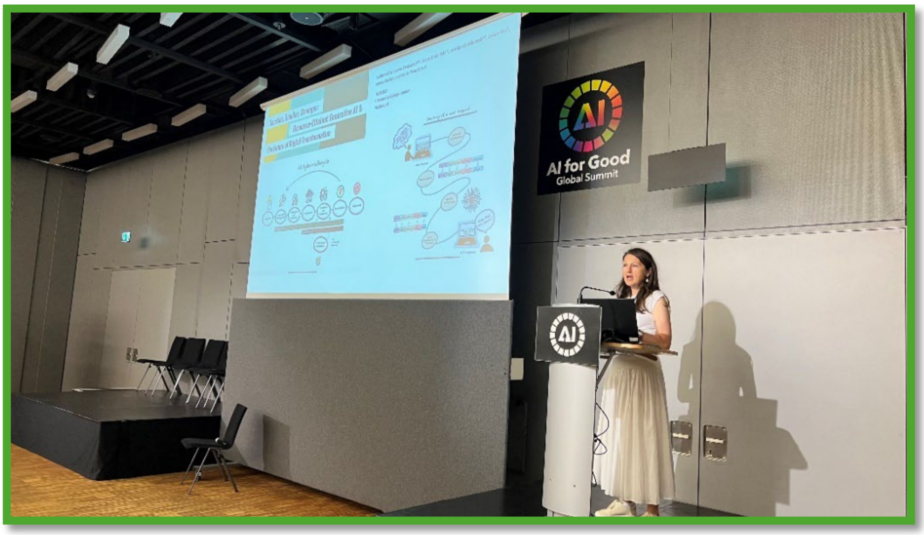
- "We need to completely rethink AI computing. The answer may lie in disruptive combinations of new hardware, software and in mathematics." – Prof. Gitta Kutyniok

- "80–90 per cent of AI's computation happens during inference and yet we barely talk about it." – Prof. Roy Schwartz

Key takeaways

- Challenging problem is to solve the energy efficiency of AI.
- Energy and inference matter: The focus must shift from large-scale model training to sustainable inference – the true computational bulk of AI.
- Hardware-software co-design is critical: Emerging architectures (neuromorphic, brain-inspired, or task-adaptive) can cut energy consumption dramatically, as shown in the use of small models and analogue systems.
- Green AI must become the norm, not the exception – through better compute reporting, evaluation metrics and research funding incentives.
- Standards and benchmarks are needed for:
  - Model-level energy reporting
  - Inference efficiency metrics
  - Lifecycle footprint of AI chips and cooling systems
  - Frugal AI design methodologies
- Opportunities for ITU:
  - Support development of standardized AI energy efficiency frameworks, potentially building on ongoing work under ITU-T Study Group 5 and considering developing a worldwide "Green AI" label.
  - Consider developing new technical specifications on sustainable AI deployment, data centre optimization, and model auditing protocols

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Session 3: AI-driven environmental sustainability across industries (1400–1545)

Main discussion

This session examined the intersection of AI and environmental sustainability across diverse sectors. Presenters discussed both practical implementations and theoretical frameworks aimed at aligning AI development with climate and ecological goals.

The session was moderated by **Yolanda Martínez (World Bank)**, who highlighted the potential of AI and other emerging technologies to enhance efficiency, drive innovation and reduce environmental impacts across sectors.

- **Amine Saboni (Pruna AI / CodeCarbon)** presented CodeCarbon, an open-source tool that tracks CO_2 emissions from code execution and provides actionable insights for researchers, developers, and data scientists. He emphasized that AI's footprint extends beyond CO_2 emissions to water usage and hardware manufacturing, and highlighted Scope 1–3 impacts:
    - Scope 1: direct cooling emissions from data centres
    - Scope 2: emissions from electricity used
    - Scope 3: chip production and infrastructure
      Saboni offered concrete mitigation techniques such as model pruning, quantization, distillation, and optimized training locations, while encouraging users to "use the smallest model for your need" and extend the lifespan of hardware.
- **Björn Ommer (LMU Munich)** addressed the critical sustainability risks of generative AI, warning that hardware growth cannot match model scale, leading to bottlenecks and centralization of power. He called for:
    - Cost-effective, generalizable models
    - Repurposing pretrained models for new use cases
    - Open-source ecosystems to ensure transparency and democratized development
    - Greater efficiency through edge computing and modular designs
- **Li Cui (ZTE Corporation)** outlined ZTE's vision of a three-tier strategy for green AI:
    - Efficient Infrastructure: enhancing computing and cooling through distributed architecture and energy-aware networking, in particular when developing high-speed networks.
    - Intelligent Empowerment: optimizing AI through multimodal learning and model compression techniques
    - Efficient Implementation: deploying AI across sectors such as smart grid, disaster warning, green finance, and personalized energy tracking. And she emphasized that global collaboration and human-centered principles are necessary to balance innovation with energy constraints.
- **Carlos Souza Jr. (Imazon)** introduced PrevisIA, a project that applies AI to predict and prevent deforestation in the Amazon. The system integrates remote sensing and geospatial AI to assess risk factors like proximity to roads, showing that 95 per cent of

deforestation occurs within 5.5 km of roads. PrevisIA supports enforcement actions (e.g., fines, licensing suspensions) and empowers authorities with real-time alerts.

- **Dietram Oppelt (UNFCCC TEC Chair)** launched the TEC's technical paper on AI for Climate Action, which focuses on applications in developing countries, including:
  - Mitigation: energy optimization, emissions tracking, and renewable energy
  - Adaptation: early warning systems and localized services for smallholder farmers
  - Policy with practices to accelerate and transfer climate actions to developing countries
  - Governance: responsible AI frameworks to mitigate risks in fragile contexts

Quotes

- "We need to make AI less thirsty – not just in terms of energy, but also water and hardware usage." – Amine Saboni
- "We must not allow generative AI to become a centralized resource controlled by a few – transparency and efficiency are key to sustainability." – Björn Ommer

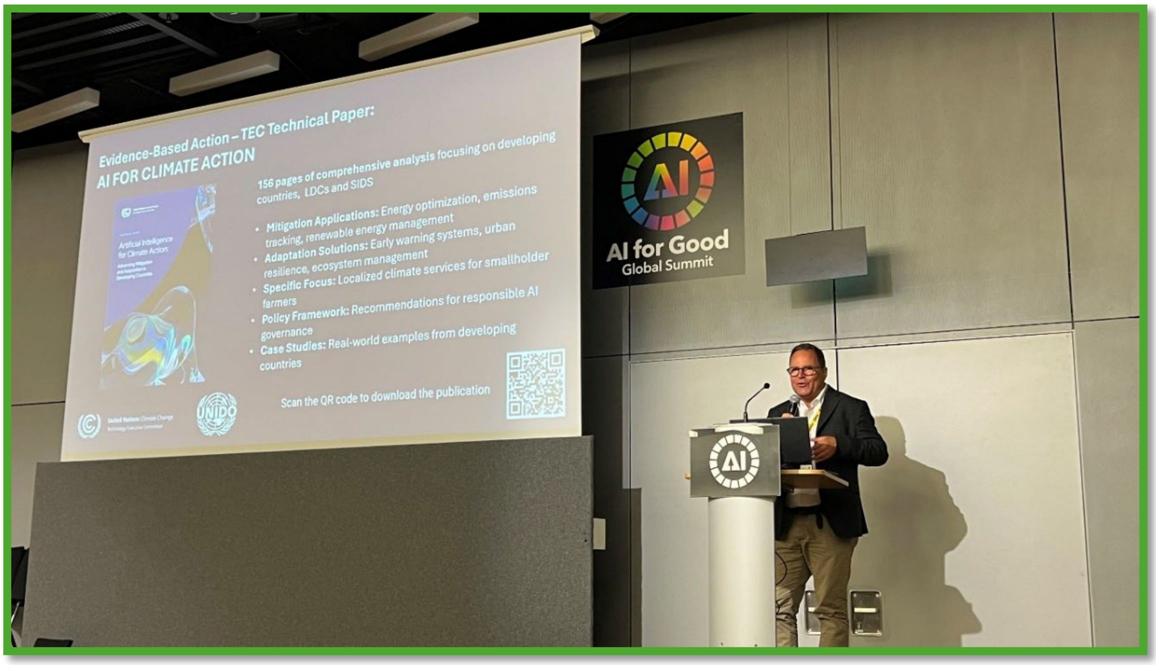
Key takeaways:

- AI's environmental impact is multidimensional, encompassing emissions, water, material extraction and infrastructure. Inference and deployment now dominate energy use, not just model training.
- Some tools (also open-source tools) offer practical pathways for emissions estimation and reduction, aligning developers' daily work with sustainability goals.
- Hardware limits are a real constraint – and unless addressed through model efficiency, AI scalability will become unsustainable.
- Sectoral applications (e.g., deforestation prevention, smart energy, public health) showcase AI's potential for impact — if implemented responsibly.
- Global equity must remain central. The TEC paper shows AI must be tailored to developing countries' needs, with appropriate governance and capacity-building.

Opportunities for ITU-T Study Group 5

- Support the development of standardized metrics and tools (e.g., model-level energy benchmarks, lifecycle impact metrics).
- Collaborate on guidelines for responsible AI deployment in climate-sensitive and resource-constrained environments.
- Facilitate cross-sector knowledge-sharing and open innovation platforms to promote scalable, low-impact AI solutions.


Yolanda Martinez
The World Bank


Evidence-Based Action – TEC Technical Paper:
AI FOR CLIMATE ACTION
156 pages of comprehensive analysis focusing on developing countries, LDCs and SIDS
Mitigation Applications: Energy optimization, emissions tracking, renewable energy management
Adaptation Solutions: Early warning systems, urban resilience, ecosystem management
Specific Focus: Localized climate services for smallholder farmers
Policy Framework: Recommendations for responsible AI governance
Case Studies: Real-world examples from developing countries
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Session 4: Standards, policies and regulations for sustainable AI and environment

Main discussion

This session addressed the urgent need for regulatory frameworks and international standards to guide the sustainable deployment of artificial intelligence (AI) in the energy and ICT sectors. Panellists emphasized the importance of data transparency, institutional cooperation, and the alignment of national policies with global climate goals.

The session was moderated by Mr. Dominique Würges (Chair of ITU-T Study Group 5, France), who emphasized the need to clearly define the role of governments and regulators in addressing the environmental impacts of AI.

- **Lina María Duque Del Vecchio (CRC Colombia)** shared insights from Colombia's data centre regulation project, which aims to improve the transparency and environmental accountability of digital infrastructure. She highlighted Colombia's effort to collect data on energy consumption and GHG emissions, while acknowledging that political resistance and lack of private sector participation remain major obstacles. She called for regional cooperation and harmonized standards, particularly for reporting frameworks that could be adopted across Latin America.
- **Eugênio Vargas Garcia (Ministry of Foreign Affairs, Brazil)** offered a national perspective in the lead-up to COP30, which Brazil will host. He emphasized Brazil's commitment to environmental protection and climate diplomacy, noting the centrality of sustainable digital transformation and AI governance in shaping Brazil's COP30 priorities. He stressed the need to embed AI energy regulation into the broader UNFCCC agenda and encouraged multilateral institutions like ITU to scale support for capacity-building in emerging economies.
- **John Omo (ATU)** underlined the regulatory and infrastructural gaps in Africa that challenge sustainable AI deployment. He advocated for fit-for-purpose standards that reflect the realities of developing and least developed countries, especially where digital access is still limited. He noted that the ICT sector can play a dual role in accelerating access to energy through smart grids and reducing its own footprint, but only if regulators are equipped with the right tools and data.
- **Laure de la Raudière (ARCEP France)** highlighted France's and the EU's work on digital environmental regulation, referencing the European Data Act and energy performance monitoring of data centres. She advocated for binding obligations for AI developers and data centre operators, including disclosure of energy intensity, carbon footprint, and water usage. She also emphasized the importance of collaborative standardization through ITU, suggesting closer alignment between national regulators and global standard-setting bodies, and recalling the importance of data measurement at the international level

Key takeaways:

- Data access remains a bottleneck: several panellists echoed the need for greater transparency and political will, especially from the private sector, to disclose energy consumption and GHG emissions data. This is essential for developing effective regulation and standards.

- Regulatory frameworks must adapt to the dual nature of AI as a tool for energy optimization as well as a source of energy demand. This calls for a systems-level regulatory approach, integrating AI policy with climate and digital infrastructure policy.
- Developing countries need support: capacity building for policymakers and regulators – particularly in Africa and Latin America – is essential for ensuring a just and inclusive digital transition.
- ITU's role is pivotal: ITU-T SG5 was recognized for its leadership in environmental standardization. Calls were made to accelerate the adoption of ITU recommendations (e.g., ITU-T L.1472, L.EnvAI, and emerging guidelines on sustainable data centres).
- Towards COP30: The session framed COP30 as a strategic moment to embed digital sustainability and AI governance into global climate action, with Brazil offering to take a leading role.

Opportunities for ITU-T SG5

- Facilitate the creation of a global reporting framework for AI-related energy and emissions data, in cooperation with national regulators.
- Support governments in adapting ITU standards to local contexts, with technical assistance, training, and multistakeholder engagement.
- Collaborate with regulators like CRC, ARCEP, and ATU to co-develop policy toolkits that guide sustainable digital infrastructure development and AI deployment.


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