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Contact:	Leo Solga University of Pennsylvania United States of America	Tel: +1-610-500-4982 E-mail: solgaleo@sas.upenn.edu
Contact:	Alexander Schrier University of Pennsylvania United States of America	Tel: +1-301-538-8665 E-mail: aschrier@sas.upenn.edu

Abstract: As artificial intelligence (AI) becomes increasingly integral to global innovation, its environmental footprint—particularly through energy-intensive data centers—raises urgent sustainability concerns. This report, developed for the International Telecommunication Union (ITU), investigates AI regulation and proposes standard development under World Telecommunication Standardization Assembly (WTSA) Resolution 73. It recommends two primary initiatives: (1) a voluntary International Scoring Model (ISM) to assess and incentivize energy-efficient AI data centers using the Product Parameter (PP) approach, and (2) a global awareness campaign to promote responsible AI development and highlight AI's potential to advance environmental goals. Together, these measures aim to align AI growth with climate action, supporting the United Nations (UN) Sustainable Development Goals and ITU's commitment to environmentally sustainable Information and Communication Technology (ICT) standards.

Capstone Project for the International Telecommunication Union

RECOMMENDATION BY PERRY WORLD HOUSE

From Code to Carbon: Responding to the Environmental Impact of Artificial Intelligence

By Alexander Schrier, Keanu Nahmi Natan, Zachary McGrath, Leo Solga, David Garcia-Maldonado

(2025)

Introduction - Impact of Artificial Intelligence

The International Telecommunication Union (ITU) is the specialized agency of the United Nations for information and communication technologies (ICTs). The ITU plays a vital role in advancing the use of ICTs to protect the environment, address climate change, and promote circular economy practices. This commitment is underscored by its mandate as outlined in key resolutions adopted by its membership, including Plenipotentiary Resolution 182[1] on the role of ICTs in regard to climate change and environmental protection; WTDC Resolution 66[2] on ICT, environment, climate change, and circular economy; and WTSA Resolution 73 on ICTs, environment, climate change, and circular economy.[3]

Artificial Intelligence (AI) is both a transformative force and solution in the future of ICT, driving innovation while addressing complex challenges across the digital ecosystem. Since the release of OpenAI's "ChatGPT" model in December 2022, for many, accessible generative AI has become an integral part of everyday life.[4] In three short years, AI has also emerged as a potential resource in ongoing global efforts to protect and preserve the natural world.[5] However, AI's future benefits may be overshadowed by the parallel environmental challenges it presents.

The environmental costs of data centers, the bedrock of AI systems, manifest these challenges. 2024 estimates suggest that 20% of data center resources are directed at maintaining AI systems.[6] As of 2025, data centers have already surpassed the global aviation industry in greenhouse gas emissions

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[1] *Final Acts of the Plenipotentiary Conference Bucharest, 2022* (Geneva: International Telecommunication Union, 2022).

[2] *Resolution 66 (Rev. Kigali, 2022): Information and Communication Technology, Environment, Climate Change and Circular Economy*, World Telecommunication Development Conference, 6–16 June 2022, Kigali, Rwanda (Geneva: ITU, 2022).

[3] Resolution 73 (Rev. New Delhi, 2024): Information and Communication Technologies, Environment, Climate Change and Circular Economy, World Telecommunication Standardization Assembly, 15–24 October 2024, New Delhi, India (Geneva: ITU, 2024).

[4] Weise, Karen, Cade Metz, and Tripp Mickle. "Inside the A.I. Arms Race That Changed Silicon Valley Forever." *The New York Times*, October 22, 2023. https://www.nytimes.com/2023/10/22/technology/ai-silicon-valley.html.

[5] Masterson, Victoria. "9 Ways AI Is Being Deployed to Fight Climate Change." *World Economic Forum*, January 17, 2024. https://www.weforum.org/agenda/2024/01/ai-climate-change-solutions/.

[6] Chow, Andrew R. "How AI Is Fueling a Boom in Data Centers and Energy Demand." *TIME*, February 27, 2024. https://time.com/6663333/ai-data-centers-energy-demand/.

at 2.5% to 3.7% of total global emissions.[7] Further, as noted in a 2024 report, these centers consume copious water and energy resources.[8] The costs of data centers and AI's share of their resources will only increase.[9]

This paper aims to support the ITU in its work under WTSA Resolution 73 by exploring the environmental implications of AI and proposing potential avenues for action. Two key recommendations emerge from our work: establishing an ITU scoring model for green AI data centers and launching an education campaign on AI environmental sustainability. The ITU scoring model would create an international standard that rates AI data centers based on their level of energy efficiency. Meanwhile, the education campaign would showcase the environmental costs of creation and use of AI data centers while highlighting how AI can help address broader environmental challenges. Along with delivering the mandate from ITU member states, our recommendations actively support the UN's sustainable development goals on quality education; industry, innovation, and infrastructure; responsible consumption and production; and climate action.[10]

Background - Turning a Resolution into Action

Numerous international organizations and several ITU member states have shown initiative in taking action and measuring AI's environmental impact. The European Union passed the EU Artificial Intelligence Act —legislation regulating "high-risk" AI systems. The United States has chief AI officers in each of its federal agencies.[11] The United Kingdom's Royal Academy of Engineering has been tasked with developing a report to advise the government on using AI to provide solutions to climate change and align AI development with its environmental goals.[12] The French Republic hosted the AI Action Summit alongside the ITU.[13] However, some ITU member states' calls for environmentally-focused action regarding AI have yet to manifest into formal legislation.

In response to WTSA Resolution 73, the ITU develops standards to measure ICT's environmental impact. Recommendation ITU-T L.1410 "Methodology for environmental life cycle assessments of information and communication technology goods, networks and services" which was revised in

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[7] Monserrate, Steven Gonzalez. "The Staggering Ecological Impacts of Computation and the Cloud." *MIT Technology Review*, April 15, 2022. https://www.technologyreview.com/2022/04/15/1048981/environmental-costs-cloud-computing/.

[8] Spindler, Wesley, Luis Neves, and Cristina De La Cruz. "Circular Water Solutions Key to Sustainable Data Centres." *World Economic Forum*, January 25, 2024. https://www.weforum.org/agenda/2024/01/sustainable-data-centres-water-circular-economy/.

[9] "AI to Drive 165% Increase in Data Center Power Demand by 2030," *Goldman Sachs*, February 5, 2025, https://www.goldmansachs.com/intelligence/pages/ai-to-drive-165-increase-in-data-center-power-demand-by-2030.html.

[10] "The 17 Sustainable Development Goals." *United Nations*, accessed May 5, 2025, sdgs.un.org/goals.

[11] "Fact Sheet: Eliminating Barriers for Federal Artificial Intelligence Use and Procurement." *The White House,* April 7, 2025, https://www.whitehouse.gov/fact-sheets/2025/04/fact-sheet-eliminating-barriers-for-federal-artificial-intelligence-use-and-procurement/.

[12] Royal Academy of Engineering, *Engineering Responsible AI: Foundations for Environmentally Sustainable AI* (London: Royal Academy of Engineering, February 2025), https://raeng.org.uk/media/2aggau2j/foundations-for-sustainable-ai-nepc-report.pdf.

[13] "Standardization for AI Environmental Sustainability." *AI Action Summit*, February 11, 2025.

November 2024, establishes definitions and formulas for calculating ICT's environmental impact.[14] More specifically, ITU-T L.1410 formalizes Life Cycle Assessment (LCA) methodologies into standards approved by the ITU, where ICTs are evaluated at each stage of their lifecycle. As the next step toward using LCAs to measure the impact of ICTs, ITU-T study groups have developed a simplified method denominated as the Product Parameter (PP) approach.[15]

We identify the PP as the most suitable framework to assess the environmental impact of AI, as it operationalizes a relatively simple theoretical model to measure the complex life cycle of AI systems and estimate their total carbon emissions. The PP method assesses specific parameters—such as weight, surface area, and elemental composition—which are then multiplied by an Emissions Factor (EF) to calculate the total carbon emissions associated with the full AI life cycle. For more information on the PP, see Appendix A. As the PP remains under development, current limitations include its reliance on EFs (which are largely theoretical) and its exclusive focus on carbon emissions, without accounting for other environmental concerns such as water usage. As future literature develops, the PP model—valued for its flexibility, simplicity, and broad applicability—could incorporate water usage as a key variable.

Recommendations - Implementing International Standards (ITU-T Recommendations)

The recent drive to form standards from national, supranational, and multilateral institutions now enables the ITU to develop recommendations for its member states to address the environmental impact of AI, fulfilling its mandate from WTSA Resolution 73. Given these standards, our team has drawn upon economics and international relations theory to develop two recommendations for the ITU to present to its members:

1. Develop an International Scoring Model (ISM) that rates the energy efficiency of AI data centers using a grade-based system. These scores would employ the PP approach to measure the energy inputs of AI data centers and evaluate their environmental performance.

Our ISM would be voluntary for member states and AI stakeholders to assess data center sustainability. The ISM would aim to incentivize participants in the competitive AI landscape to invest in environmentally friendly data centers. In other words, stakeholders may not want to fall behind in the race to develop cutting-edge AI, so they may endorse the ISM and invest in more environmentally sustainable data centers. Additionally, countries with high sustainability rankings may gain the ITU's sustainability endorsement and a competitive advantage in hosting green AI infrastructure.

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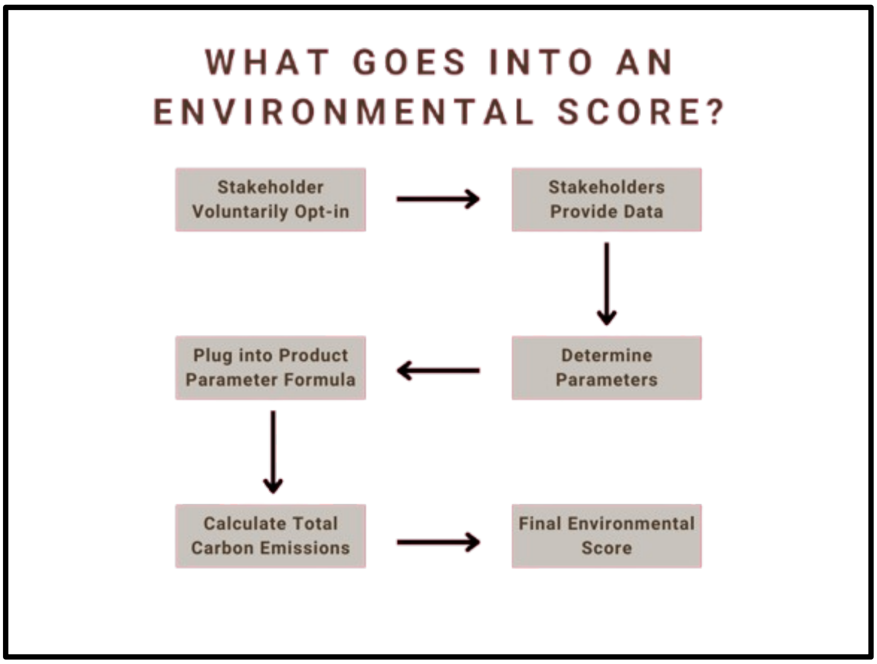
[14] *Recommendation ITU-T L.1410 (11/2024): Methodology for Environmental Life Cycle Assessments of Information and Communication Technology Goods, Networks and Services.* Geneva: ITU, November 2024.

[15] *Draft Recommendation ITU-T L.SimplifiedLCA: Guidance on Simplified Life Cycle Assessments of Information and Communication Technologies* (output of the joint ETSI TC EE Q9/5 Rapporteur e-meeting held on 28 November 2024) [draft report] (Geneva: ITU, 2024).



2. Launch an awareness campaign in collaboration with research institutions, academia, public organizations, and other UN bodies (such as the UN Framework Convention on Climate Change) to educate stakeholders (consumers, developers, and policy-makers) about how AI can be leveraged for positive environmental outcomes and best practices for developing environmentally sustainable AI data centers.

Recommendation 2 sets out to utilize the ITU's global outreach capabilities to construct norms on how to mitigate the environmental impact of AI and use it for positive results. According to Golestan Radwan, the Chief Digital Officer of UNEP, "There is still much we don't know about the environmental impact of AI but some of the data we do have is concerning…"[16] Delivering this message to legislators and constituents of ITU member states, and conveying what we currently know about green solutions, may generate more sustainable approaches and new environmental norms.

Conclusion - Adapting to a Changing Field

The ITU is uniquely positioned to provide impactful advice to the world. While AI is a fast-moving sector, the ITU has already stepped up to provide robust, well-researched standards and methodologies. Continuing in this tradition, we propose two lines of action: (1) a voluntary ISM and (2) an in-depth awareness campaign. While measuring the environmental impact of AI poses challenges—such as accounting for water usage—we believe that our recommendations have established a baseline for future regulation. These programs recognize the rapidly evolving nature of AI in relation to its environmental impact and will provide an opportunity for the ITU to support the many national, supranational, and multilateral institutions striving to ensure AI development is sustainable, inclusive, and forward-thinking.

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[16] "AI Has an Environmental Problem. Here's What the World Can Do about That." *UNEP*, September 24, 2024, https://www.unep.org/news-and-stories/story/ai-has-environmental-problem-heres-what-world-can-do-about.

Appendix A: Product Parameter Approach

The inherent complexity of AI systems presents significant challenges in quantifying its environmental impact. AI affects climate change, resource extraction, and water usage, among other environmental concerns. Requiring states to track every minor environmental impact of AI would be impractical and could detract from addressing the most significant issues.

To help remedy this issue, "simplified Life Cycle Assessments" (LCA) methodologies may be implemented by governments to ease the measurement process. According to ITU L.1410, an LCA is a "systematic analytical method" to measure the environmental effects of information and communication technology (ICT).[17] "LCAs have a cradle-to-grave scope where all the life cycle stages (raw material acquisition, production, use, and end-of-life treatment) are included." This balance between recognizing AI systems' complexity while taking a theoretical approach makes LCA's extremely useful for evaluating AI's environmental impact.

While analysts use various LCA methodologies, the Product Parameter (PP) approach is particularly well-suited for evaluating AI systems. The PP method aggregates the high-impact parameters of each stage of ICT lifecycle in order to measure its environmental impact (e.g. weight, quantity, area, volume). This approach has been developed from the Draft Recommendation ITU-T L.SimplifiedLCA "Guidance on simplified life cycle assessments of Information and Communication Technologies"- Output of the joint ETSI TC EE Q9/5 Rapporteur e-meeting held on 28 November 2024.[18]

In this method, environmental impact is generally measured in greenhouse gas emissions (GHG). To measure GHG emissions, an "Emission Factor" (EF) is multiplied onto the corresponding parameter. EF's are not globally standardized and can be calculated in a number of ways — from finding global averages that correspond to a certain emission activity, to primary observation. Past LCA studies have their own EF's that may be substituted, as does other published literature. Thus, in each stage of an AI's lifecycle, each parameter, or emission activity, is multiplied by an EF to calculate total emissions (TE).

The PP method identifies three stages of ICT's—in this case AI's—lifecycle:

1. Cradle to Gate (CG): Encompasses carbon-intensive activities from raw material acquisition through hardware production until the product leaves the factory.
2. Use Phase (UP): Covers the period of active system usage: AI training and deployment.
3. End-of-Life (EOL): Involves system disposal and recycling. This stage is particularly significant for AI hardware, as improper disposal of e-waste can release toxic chemicals into the environment.

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[17] *Recommendation ITU-T L.1410 (11/2024).*

[18] *Draft Recommendation ITU-T L.SimplifiedLCA.*

Cradle to Gate

In CG, users of the PP method create a Bill of Material of the AI hardware which consists of the raw materials utilized to build it. Then, users identify the parameters of those materials and multiply them by an EF to generate the total amount of GHG from each material. Parameters include but are not limited to weight, area, and material composition of the hardware piece. CG also included the emissions generated from factories and transportation services utilized to deliver the AI hardware. Below is a simple equation that calculates GHG in the CG phase:

$$CGCF = \Sigma\,(PP_n * f_n * EF_n) + TR + F$$

Where CGCF is the total amount of GHG emitted during the CG phase, PP_n represents the parameter of a specific material, f_n is the "corresponding factor" that represents material losses during production, EF_n is the EF for the material, TR is carbon emitted from transportation, and F is carbon emitted from production.

Usage

The GCG from UP only consists of the emissions during the training and general usage phases. In this case, the equation to calculate GHG is:

$$UCF = AEC * ALY * EEF$$

Where UCF is total GHG during UP, AEC is annual electricity consumption, ALY is active lifetime years of an AI product, and EEF is the EF for electricity. UP is generally simple to calculate and not as complex relative to the other calculations.

End-of-Life

L.1410 does not provide a specific formula for calculating total GHG emissions from the EoL phase (EoLCF). The PP method can optionally include the EoL stage, using allocation methods like the 50/50 method, which divides responsibility between primary material production and recycling. In these simplified approaches, the EoL stage covers more than just transportation and improperly recycled e-waste—it also includes collection and processing.

Total Emissions

With all emissions of each phase taken into account, this equation accounts for the total amount of emission TCF calculated through the PP approach:

$$TCGC = CGCF + EoLCF + UCF$$

The above equations marks the final step in the PP approach. Having calculated TCGC, one can split it annually or maintain the total amount. Either way, GHG emissions are very straightforward and generally simplified so that the approach can be adopted by a wide range of actors (businesses, governments, etc).