

ISSN: 2583-8725

Lex Scripta Journal

Quarterly Online and Print Edition

Law & Policy

“Join the League of
National & International Scholars”



EDITORIAL TEAM

DR. AJAY BHUPENDRA JAISWAL

Professor & Former Head
Department of Law
V.S.S.D. College, Nawabganj,
(C.S.J.M. University, Kanpur)

DR. MEGHA OJHA

Associate Professor | Legal Consultant
| Author | KLEF College of Law

PROF. DR. DEEVANSHU SHRIVASTAVA

Founding Dean and Professor,
GL Bajaj Institute of Law,
Greater Noida

DR. GAURAV GUPTA

Assistant Professor,
Faculty of Law, Lucknow

MR. TUHIN MUKHARJEE

Leadership Strategist | Business Coach
| Author | Speaker

MR. PRAKARSH PANDEY

Author and
Advocate, Allahabad High Court

MR. AMARESH PATEL

Assistant Professor
at Law School,
Amity University, Patna



**LEX SCRIPTA MAGAZINE OF
LAW AND POLICY (VOL-4, ISSUE-1)**

Copyright © 2025, LexScripta

ISSN-2583-8725

Vol - IV, Issue - I

Published by INTEGRITY EDUCATION INDIA

New Delhi

First Floor, 4598/12-B, 1st Floor,
Padam Chand Marg, Daryaganj,
New Delhi, Delhi 110002

Phone: +91 98 11 66 62 16 (M)

Phone: +91 70 11 60 56 18 (M)

Bengaluru

Jallahalli East

Bengaluru, Karnataka. India.

Phone: +91 98 11 66 62 16 (M)

Email: publisher.integrity@gmail.com

USA

New Jersey

14 Grandview Ave, Upper Saddle River,
NJ-07458, USA

Phone: +14805226504 (M)

London

37 Degree Media

64, Hodder Drive, Perivale, London UB68LL.
United Kingdom.

Phone: +44 7950 78 18 17 (M)

Website: integrityeducation.co.in

© Lex Scripta Magazine Of Law And Policy, 2025

Disclaimer

All Copyrights are reserved with the Authors. But, however, the Authors have granted to the Journal (Lex Scripta Magazine of Law and Policy), an irrevocable, non-exclusive, royalty-free and transferable license to publish, reproduce, store, transmit, display and distribute it in the Journal or books or in any form and all other media, retrieval systems and other formats now or hereafter known. No part of this publication may be reproduced, stored, distributed, or transmitted in any form or by any means, including photocopying, recording, or other electronic or mechanical methods, without the prior permission of the publisher, except in the case of brief quotations embodied in critical reviews and certain other non-commercial uses permitted by copyright law.

The Editorial Team of Lex Scripta Magazine of Law and Policy Issues holds the copyright to all articles contributed to this publication. The views expressed in this publication are purely personal opinions of the authors and do not necessarily reflect the views of the Editorial Team of Lex Scripta Magazine of Law and Policy.

[© Lex Scripta Magazine of Law and Policy. Any unauthorized use, circulation or reproduction shall attract suitable action under application law.]

For any Query / Feedback
Phone: +91 98 11 66 62 16 (Vineet Sharma)

Printed in India @ New Delhi

ISSN: 2583-8725

Lex Scripta Journal

Quarterly Online and Print Edition

Law & Policy

"Join the League of National
and International Scholars"



Lex Scripta Journal

Green Computing and Energy-Efficient Data Centres: A Legal Perspective

Author

Vanshika Chauhan



Green Computing and Energy-Efficient Data Centres: A Legal Perspective

Vanshika Chauhan

Amity law school Noida (A032134721124)

Ba llb (i) 10th sem

Abstract

The rapid growth of digital technologies, cloud computing, and artificial intelligence has significantly increased the energy consumption and environmental impact of data centres worldwide. This paper examines the concept of green computing and the development of energy-efficient data centres from a legal and sustainability perspective. It analyses the environmental challenges associated with data centres, including carbon emissions, excessive electricity use, electronic waste, and resource depletion. The study further explores existing legal frameworks, regulatory gaps, corporate environmental responsibilities, and emerging policy challenges linked to sustainable IT infrastructure. In addition, the paper highlights technological solutions such as virtualization, renewable energy integration, intelligent cooling systems, and AI-driven energy management aimed at improving efficiency and reducing environmental harm. The research concludes that although significant progress has been made in promoting green computing practices, the absence of a unified global regulatory framework continues to hinder effective implementation. The paper recommends stronger international cooperation, standardized sustainability metrics, and stricter e-waste and energy-efficiency regulations to ensure that technological advancement aligns with environmental protection and sustainable development goals. ^{[2] [3] [4]}

Introduction

The digital economy relies heavily on data centres, which store, process, and disseminate vast amounts of information. However, these facilities consume enormous amounts of electricity and contribute to carbon emissions. Green computing has emerged as a response to these challenges, promoting environmentally sustainable practices in IT operations.

This dissertation addresses the intersection of environmental law, technology law, and corporate governance in regulating data centre sustainability.

Background of the Study

Here's a more natural, human-friendly version of your paragraph:

1. As digital services continue to grow at an unprecedented pace, data centers have become essential to modern life. However, this rapid expansion comes with a downside they consume massive amounts of energy and contribute significantly to carbon emissions. Green computing aims to address this challenge by promoting environmentally responsible IT practices. This includes improving energy efficiency, reducing electronic waste, and making greater use of renewable energy sources.
2. This paper explores the key principles behind green computing and examines practical strategies for building more energy-efficient data centers. These strategies include techniques like server consolidation, virtualization, advanced cooling systems, and the integration of renewable energy. At the same time, it also discusses the major challenges

faced in adopting these approaches, such as high initial costs, outdated infrastructure, and fluctuating workloads.

3. Finally, the paper looks ahead to emerging solutions that could shape the future of sustainable computing. Innovations like AI-driven energy management, liquid cooling technologies, and carbon-aware scheduling offer promising ways to reduce the environmental impact of data centers while meeting growing digital demands.
4. If you want, I can make it more formal, simpler, or tailored for a specific audience (like a presentation or abstract).

Growth of digital economy

Data centres play a vital role in powering the digital world, but their environmental footprint is both significant and steadily increasing. Behind every cloud service, video stream, or AI model lies a network of facilities that consume large amounts of energy, rely on physical resources, and generate waste. Understanding their impact helps explain why sustainability has become such an important focus in the tech industry.

One of the biggest concerns is **energy consumption**. Globally, data centres are responsible for about **1% to 2% of total electricity use**, which is already substantial and growing fast. In the United States, for example, their share of electricity consumption rose from **1.9% in 2018 to 4.4% in 2023**, and projections suggest it could climb as high as **12.7% by 2028**. A major driver of this surge is the rapid expansion of **artificial intelligence**, which requires enormous computing power and, in turn, more energy-hungry infrastructure.

This heavy energy use directly contributes to **greenhouse gas emissions**. Data centres account for roughly **2% of global CO₂ emissions**, putting them on par with the aviation industry. The issue isn't just how much energy they use, but where that energy comes from. In many regions, electricity is still generated from fossil fuels, meaning every server running in a data centre may indirectly contribute to climate change.

Another often overlooked impact is **water consumption**. Keeping thousands of servers running generates intense heat, and cooling systems are essential to prevent overheating. Many facilities rely on water-based cooling methods, using large volumes of water for temperature regulation and humidity control. In fact, cooling alone can account for more than **40% of a data centre's total energy use**, making it both an energy and water-intensive process.

Then there's the issue of **electronic waste**, or e-waste. Data centre hardware servers, storage devices, networking equipment has a relatively short lifespan due to rapid technological advancements. As companies upgrade to stay competitive, older equipment is discarded. In 2023, the world generated over **53 million metric tons of e-waste**, but only about **17% was properly recycled**. The rest often ends up in landfills, where hazardous materials like lead, mercury, and cadmium can leak into the environment, contaminating soil and water.

The environmental impact doesn't begin or end with usage it spans the entire lifecycle of the equipment. This is known as **embodied carbon**. From mining raw materials and manufacturing semiconductors to transporting, installing, and eventually disposing of hardware, each stage consumes energy and resources. For instance, producing a single laptop

can release **300 to 500 kilograms of CO₂**, and servers require even more intensive processes involving large quantities of water, rare minerals, and chemicals.

Data centres also generate significant amounts of **waste heat**. As servers process data, they release heat that must be managed to maintain performance. In most cases, this heat is simply expelled into the surrounding environment, effectively wasting energy. While some innovative facilities are beginning to capture and reuse this heat for example, to warm nearby buildings this practice is not yet widespread.

Finally, there are broader environmental concerns related to **land use and material toxicity**. Building large-scale data centres requires substantial physical space, which can disrupt local ecosystems. Additionally, the materials used in electronic components can pose long-term environmental risks if not handled and disposed of properly.

Rise of data centres globally and in India

The **global data centre market** is growing at a remarkable pace, reflecting just how dependent the world has become on digital services. In 2022 alone, spending in this sector reached around **\$216 billion**, and that number continues to climb. This surge isn't happening in isolation it's being driven by the rapid rise of technologies like **artificial intelligence (AI)**, cloud computing, streaming platforms, and the ever-expanding network of connected devices through the Internet of Things (IoT). Every time data is stored, processed, or transferred, it relies on these facilities working behind the scenes.

1 Global Growth and Rising Energy Demand

As data centres expand, so does their appetite for energy. At present, they account for roughly **1% to 2% of global electricity consumption**. While that might sound modest, it represents a massive and continuously increasing load on power systems worldwide.

In the **United States**, the growth is especially striking. Data centres used about **1.9% of the country's electricity in 2018**, but that figure rose to **4.4% by 2023**. Looking ahead, projections suggest this could reach as high as **12.7% by 2028**. A significant portion of this increase is tied to the explosive growth of AI workloads, which require far more computational power than traditional applications.

A similar trend is unfolding in **China**, where data centres are expected to consume over **400 billion kilowatt-hours of electricity by 2030**, accounting for about **3.7% of the nation's total energy use**. These numbers highlight a broader global pattern: as digital infrastructure grows, so does its energy footprint.

This rapid expansion has made **sustainability a top priority**. Rising energy costs, stricter regulations, and increasing pressure from investors and customers are pushing organisations to rethink how their data centres operate. It's estimated that by **2027, around 75% of organisations** will have adopted some form of sustainability programme for their data centres. At the same time, the broader **green computing industry** has grown into a market worth over **\$500 billion**, showing just how central efficiency and environmental responsibility have become.

2 Growth in India and South Asia

In **India and the wider South Asian region**, the data centre landscape is evolving quickly, even if detailed statistics on the exact number of facilities are still emerging. What's clear is

that demand for digital infrastructure is rising sharply, driven by increasing internet usage, digital services, and government-led initiatives around digitisation.

Looking at the region, **Bangladesh** offers a glimpse into this growth. Its National Data Centre has scaled up to operate more than **100,000 servers**, reflecting the kind of large-scale infrastructure investments being made across South Asia.

In **India**, however, this growth comes with significant environmental challenges. One of the most pressing issues is **electronic waste management**. Formal recycling rates remain **below 15%**, meaning a large portion of discarded IT equipment is not processed safely. This is particularly concerning given the rapid turnover of hardware in data centres.

At the same time, the **carbon footprint of India's IT sector is expected to double by 2025**, adding urgency to the need for sustainable practices. In response, organisations across the region are beginning to adopt greener strategies. These include **energy-aware management systems**, improved cooling technologies, and the use of simulation tools such as Green Cloud frameworks to optimise performance while reducing environmental impact.

Environmental concerns

Data centres and the wider IT sector are often seen as part of a “clean” and invisible digital world—but in reality, they come with a very real environmental footprint. As our reliance on cloud services, streaming, and especially artificial intelligence continues to grow, so does the strain these systems place on energy, natural resources, and ecosystems. In fact, if the Internet were treated like a country, its emissions would rank among the largest in the world.

Energy Consumption and Carbon Emissions

The most immediate and visible impact of data centres is their massive appetite for electricity. These facilities run 24/7, powering servers, storage systems, and networking equipment while also keeping everything cool enough to function properly.

Globally, data centres consume about 1% to 1.5% of all electricity, and that figure is climbing quickly. In the United States, for example, their share of electricity use has more than doubled from 1.9% in 2018 to 4.4% in 2023 and could reach 12.7% by 2028. A major reason behind this surge is the rise of AI, which demands far more computational power than traditional applications. Training and running large models requires vast clusters of high-performance hardware, all drawing significant energy.

This energy demand translates directly into greenhouse gas emissions, especially in regions where electricity still comes from fossil fuels. Data centres are responsible for around 2% of global CO₂ emissions, putting them on par with the aviation industry.

It's also important to understand that emissions come from two main sources:

- Operational emissions, which are produced during the day-to-day running of data centres mainly from electricity use and cooling systems.
- Embodied emissions, which are less visible but just as important. These occur during the manufacturing of servers, the construction of facilities, and the eventual disposal of equipment.

Together, these make the true carbon footprint of digital infrastructure much larger than it might first appear.

Electronic Waste (E-Waste) and Toxicity

Another growing concern is electronic waste, driven by the rapid pace of technological change. Devices and hardware are frequently replaced to keep up with performance demands, often long before they physically wear out. For example, smartphones are typically replaced every 2.5 years, and data centre equipment follows similarly short upgrade cycles.

In 2023, the world generated over 53 million metric tons of e-waste, yet only 17% was formally recycled. The rest is often dumped or informally processed, especially in developing regions.

This creates serious environmental and health risks. Electronic components contain hazardous materials like lead, mercury, and cadmium, which can leach into soil and water if not handled properly. Over time, this contamination can affect agriculture, drinking water, and entire ecosystems.

Countries such as India and Nigeria face particular challenges, with formal recycling systems handling less than 15% of e-waste. Much of the remaining waste is processed in unsafe conditions, exposing workers and communities to toxic substances.

Resource Depletion and Embodied Carbon

The environmental impact of data centres doesn't begin when they are switched on it starts much earlier, during the production of the equipment itself.

Manufacturing IT hardware is resource-intensive. Producing a single laptop, for instance, can generate between 300 and 500 kilograms of CO₂. Servers, which are far more complex, have an even larger footprint.

These processes require enormous amounts of water, energy, rare earth minerals, and chemicals. Mining for these materials can lead to deforestation, habitat destruction, and pollution. Semiconductor fabrication the process of making computer chips—is particularly demanding, consuming ultra-pure water and highly specialized chemicals.

By as early as 2015, humanity's total resource consumption had already exceeded what the Earth could sustainably regenerate each year by 50%, highlighting the pressure placed on natural systems.

Water Use and Land Occupation

Running a data centre isn't just about electricity it also requires careful environmental control. Servers generate heat, and without effective cooling, they can fail quickly.

Many facilities rely on water-based cooling systems, which use large volumes of water to regulate temperature and humidity. This becomes a serious issue in regions already facing water scarcity, where competition for water resources is high.

In addition, the physical expansion of data centres requires large areas of land. Building these facilities involves significant construction activity, which can disrupt local ecosystems, contribute to habitat loss, and generate construction waste. As demand grows, more land is being dedicated to digital infrastructure, raising questions about long-term sustainability.

Meaning and Scope of Green Computing

Green computing sometimes called sustainable computing is all about using technology in a way that's smarter, more efficient, and less harmful to the environment. Instead of simply focusing on performance and speed, it encourages organizations to think about how their computers, servers, and IT systems consume energy, use resources, and eventually get discarded.

At its core, green computing means choosing energy-efficient hardware, reducing unnecessary resource use, and handling electronic waste responsibly. This can include everything from using low-power processors and efficient servers to extending the life of equipment and recycling old devices properly. The idea is simple: get the most value out of technology while creating the least environmental impact.

Why Green Computing Matters to Organizations

For many companies, green computing isn't just a technical choice it's part of a broader commitment to responsible business practices. It often falls under environmental, social, and governance (ESG) initiatives, where organizations aim to operate in a way that's ethical, sustainable, and transparent.

There are a few key reasons why businesses are investing in green computing:

- **Cost savings:** Energy-efficient systems consume less power, which can significantly reduce electricity bills especially in large IT environments like data centres.
- **Regulatory pressure:** Governments around the world are introducing stricter rules around energy use, emissions, and waste management.
- **Environmental responsibility:** With growing awareness of climate change, companies are under increasing pressure from customers, investors, and employees to reduce their environmental footprint.

In many ways, green computing has become essential for long-term business sustainability, helping organizations stay competitive while also doing the right thing.

What Goes Into a Green Computing Strategy

Most green computing efforts start in areas that consume the most energy especially data centres, server rooms, and storage facilities. These environments run continuously and require not just power for computing, but also additional energy for cooling.

One of the simplest and most effective steps is upgrading outdated equipment. Older systems tend to use more electricity and generate more heat, which then increases cooling requirements. Modern hardware, on the other hand, is designed to be far more energy-efficient. Another common approach is improving how equipment is arranged and cooled. For example, hot aisle and cold aisle layouts organize servers based on how they release heat. This makes cooling systems more effective and reduces the overall energy needed for air conditioning and ventilation.

Practical Steps Organizations Take

A green computing strategy usually combines multiple small improvements that together make a big difference. Some of the most common practices include:

Using smart monitoring and automation

Organizations are increasingly turning to technologies like IoT sensors and AI-based tools to monitor how energy is used in real time. These systems can analyze patterns and automatically adjust cooling, power distribution, and workload management to improve efficiency without human intervention.

Turning off unused equipment

It sounds simple, but powering down servers, computers, and peripherals when they're not in use can save a significant amount of energy. Devices like printers or backup systems, which aren't needed constantly, should only run when required.

Scheduling workloads efficiently

Instead of keeping systems running all the time, tasks can be grouped into specific time periods. This allows hardware to remain off or in low-power mode when not actively needed.

Choosing energy-efficient devices

Not all hardware is equal when it comes to power consumption. Laptops, for example, generally use much less energy than desktop computers. Similarly, modern flat-panel displays consume less power and produce less heat than older screen technologies.

Enabling automatic power management

Most modern systems include built-in features that reduce energy use, such as putting monitors and hard drives to sleep after a period of inactivity. Making sure these settings are enabled is an easy way to cut down unnecessary consumption.

Rethinking cooling requirements

Newer IT equipment is designed to operate safely at higher temperatures than older systems. This means data centres don't always need to be kept as cold as they once were, reducing the energy spent on cooling.

Managing Waste and Resources

Green computing also addresses what happens at the end of a device's life. Electronic waste (e-waste) is a growing global issue, and improper disposal can release harmful substances into the environment.

Organizations are encouraged to:

- **Reuse or refurbish equipment whenever possible**
- **Recycle devices through certified programs**
- **Follow proper regulations for safe disposal**

This not only reduces environmental harm but can also recover valuable materials from old devices.

Exploring Cleaner Energy and Cooling Options

Another important part of green computing is reducing reliance on traditional energy sources. Many organizations are now exploring renewable energy options such as wind, solar, or hydroelectric power to run their IT infrastructure.

At the same time, new cooling methods like geothermal cooling or liquid cooling systems—are being tested and adopted to improve efficiency and reduce water and energy use.

The Role of Remote Work

Interestingly, changes in how people work have also contributed to greener computing practices. The shift toward remote and hybrid work, especially after the COVID-19 pandemic, has reduced the number of employees in office spaces. This means fewer computers running

on-site, lower energy demand, and less commuting leading to an overall reduction in resource consumption.

Green computing didn't appear overnight it has developed gradually over the past few decades as technology advanced and awareness about environmental issues grew. What started as simple efforts to save energy in individual devices has now turned into a broad, system-wide approach to making IT more sustainable.

How Green Computing Has Evolved

In the early 1990s, the idea of energy-efficient computing first began to take shape. Programs like Energy Star, launched in 1992, encouraged manufacturers to design computers and monitors that used less power. Around the same time, certifications such as TCO Certification focused on reducing emissions and improving user safety and ergonomics. Back then, the focus was mostly on individual devices features like sleep mode and low-power components. By the mid-2000s, things started to change. The rapid growth of the internet led to the rise of large server farms and data centres, and suddenly energy consumption became a much bigger issue. Companies began to realize that it wasn't just about making a single computer efficient it was about managing entire facilities filled with thousands of machines. Rising electricity costs and increasing environmental concerns pushed the industry to rethink how data centres were designed, powered, and cooled.

In the 2010s, the shift toward cloud computing and virtualization marked a major turning point. Instead of running one application per physical server, virtualization made it possible to run multiple workloads on a single machine. This significantly improved resource utilization, reduced the number of physical servers needed, and lowered overall energy consumption. Cloud providers also started building large-scale, optimized data centres that were far more efficient than traditional setups.

How Data Centres Have Changed

Data centres themselves have gone through a major transformation. In the past, they were known for being extremely energy-intensive, with inefficient cooling systems and underutilized hardware.

Today, there's a clear shift toward efficiency and sustainability. Modern facilities use smarter designs and technologies such as:

- Liquid cooling, which removes heat more efficiently than traditional air cooling
- In-row cooling, which targets heat directly at the source
- Air-side economization, which uses outside air for cooling when conditions allow

These innovations help reduce both energy use and operating costs.

Another important change is the move toward sustainable infrastructure. Many organizations are now powering their data centres with renewable energy to reduce their dependence on fossil fuels. This not only lowers emissions but also helps stabilize long-term energy costs.

What's Driving This Shift

Several factors have pushed green computing from a niche idea into a mainstream priority:

- Economic benefits: Energy-efficient systems cost less to run, which is especially important for large-scale operations like data centres.
- Corporate responsibility: Companies are under increasing pressure to operate sustainably and demonstrate environmental accountability.

- **Environmental concerns:** As the digital economy grows, so does its carbon footprint, making it essential to find ways to reduce its impact.

Research Problem

Lack of specific legal framework

One of the biggest challenges slowing down the widespread adoption of green computing isn't a lack of technology it's the absence of clear, consistent rules. Right now, there's no single global framework that defines how organizations should measure, report, or improve sustainability in IT. Instead, what exists is a patchwork of guidelines, regional policies, and voluntary standards that don't always align with each other.

This lack of clarity creates confusion, makes comparisons difficult, and in some cases allows companies to appear more environmentally responsible than they actually are.

1. No Common Way to Measure Sustainability

A major issue is the lack of standardized metrics. Organizations today rely on different ways to measure efficiency, such as Power Usage Effectiveness (PUE), Carbon Usage Effectiveness (CUE), and Water Usage Effectiveness (WUE). While these metrics are useful, they are not always applied consistently. ^[5]

Different companies and even different countries may calculate things in slightly different ways. This is especially true for Scope 3 emissions, which include indirect emissions across the supply chain. Because these are harder to track, reporting methods vary widely.

The result is a confusing landscape where:

- **It's difficult to fairly compare one data centre or company with another**
- **Reports may not reflect the full environmental impact**
- **Companies can highlight only the metrics that make them look good**

This opens the door to greenwashing, where sustainability claims are exaggerated or selectively presented.

There are also frameworks like the EU Code of Conduct on Data Centre Energy Efficiency, but these are largely voluntary. They provide guidance and best practices rather than strict rules, meaning companies can choose how closely they follow them.

2. Weak and Uneven E-Waste Regulations

Another major gap lies in how electronic waste is handled globally. Despite the growing volume of discarded devices, less than 30% of countries have formal e-waste legislation in place. Even where laws do exist, enforcement is often weak. In countries like India and Nigeria, for example, formal recycling systems handle less than 15% of e-waste. The rest is often processed informally or dumped, leading to serious environmental and health risks.

This problem is made worse by:

- **Limited infrastructure for proper recycling**
- **Lack of incentives for companies to recover and reuse materials**
- **Weak monitoring and enforcement mechanisms**

As data centres continue to upgrade hardware frequently, the absence of strong e-waste policies becomes an even bigger concern.

3. Regulations Struggling to Keep Up with AI

The rapid rise of artificial intelligence has added a new layer of complexity. AI systems require massive computational power, which means more energy use but regulations haven't fully caught up.

Existing frameworks like the Greenhouse Gas Protocol provide general guidance on measuring emissions, but they don't yet offer detailed methods tailored specifically to AI systems or digital infrastructure.

There's also a major issue with transparency. A large number of AI models released in recent years don't disclose how much energy they use or how much carbon they produce. In fact, more than 80% of commercial AI models lack this kind of information.

Without mandatory reporting requirements:

- **It's hard to understand the true environmental cost of AI**
- **Policymakers lack the data needed to create effective regulations**
- **Companies are not held accountable for their impact**

At the same time, technology is evolving so quickly that existing measurement methods struggle to keep up. What works today may already be outdated tomorrow.

4. Fragmented Policies Across Regions

Another challenge is the lack of coordination between countries. Different regions have different priorities, regulations, and levels of development, which leads to policy fragmentation.

In many developing countries, the focus is still on expanding access to the internet and digital services. While this is essential, it often means that sustainability takes a back seat. As a result, green computing standards may be limited or not enforced at all.

On the other hand, more developed regions may have stricter rules but these don't always apply globally.

This creates an uneven playing field where:

- **Some companies operate under strict environmental requirements**
- **Others face little to no regulation**
- **Global companies must navigate multiple, sometimes conflicting rules**

There are also challenges when it comes to adopting new technologies. Innovative ideas like high-altitude data platforms or underwater data centres sound promising, but they face complex regulatory hurdles related to safety, design, and environmental impact. Without clear guidelines, deploying such solutions becomes difficult.

The Need for a Unified Approach

All of these issues point to the same underlying problem: the lack of a coordinated global framework for green computing.

To move forward, there's a growing need for:

- Standardized metrics that are applied consistently worldwide
- Stronger e-waste regulations with proper enforcement
- Clear reporting requirements, especially for energy-intensive technologies like AI
- International cooperation to align policies and expectations

Creating a more unified system wouldn't just make compliance easier it would also build trust, improve transparency, and help ensure that sustainability efforts are genuine and effective. In short, the technology to make computing greener already exists in many cases. What's missing is a clear, consistent set of rules to guide how it should be used.

3.2 Increasing carbon footprint of tech sector

For a long time, the information technology (IT) sector was seen as a “clean” industry something intangible, with little visible impact compared to factories or transportation. But that perception has changed. As our reliance on digital services has exploded, so has the environmental cost behind them. Today, the scale is so large that if the Internet were treated like a country, it would rank among the world's biggest polluters, highlighting just how significant its footprint has become.

A Growing Environmental Footprint

At the heart of this impact are data centres, the backbone of everything from cloud storage to video streaming and AI systems. These facilities alone consume about 1% of the world's electricity and contribute roughly 2% of global CO₂ emissions a figure comparable to the entire aviation industry. What's more concerning is how quickly this is growing. The IT sector's overall carbon footprint is expected to double by 2025, driven by increasing demand for digital services. In the United States, for example, data centre electricity use has already risen from 1.9% of national consumption in 2018 to 4.4% in 2023, and it could reach as high as 12.7% by 2028. A major force behind this surge is artificial intelligence. Modern AI systems, especially large language models, require massive computing power. While training these models is energy-intensive, the real long-term impact comes from their everyday use. The inference phase when people interact with AI can account for over 90% of total computing demand, making it a continuous and growing source of energy consumption.

Looking Beyond Daily Operations

The environmental impact of IT doesn't just come from running systems it spans the entire lifecycle of the technology we use.

Embodied carbon refers to emissions produced before a device is even turned on. This includes extracting raw materials, manufacturing components, assembling devices, and building infrastructure. For instance, producing a single laptop can release between 300 and 500 kilograms of CO₂. The process of manufacturing semiconductors—the tiny chips inside every device is particularly resource-intensive, requiring large amounts of water, energy, and specialized chemicals.

On the other hand, operational carbon comes from the day-to-day running of systems. This includes the electricity used to power servers and the energy required to keep them cool. While improvements in efficiency have reduced the energy used per device, the overall demand for digital services has grown so rapidly that these gains are often canceled out.

Why Reducing the Impact Is So difficult

Even with growing awareness and the rise of green computing initiatives, cutting down the IT sector's environmental footprint isn't straightforward. Several underlying challenges make progress difficult.

One major issue is lack of transparency. A large percentage of AI systems developed in recent years do not publicly disclose how much energy they use or how much carbon they emit. Without this information, it's hard to measure impact or hold companies accountable.

There's also a problem with inconsistent standards. Different organizations use different methods to measure sustainability, making it difficult to compare performance. This lack of standardization can sometimes lead to greenwashing, where companies highlight selective data to appear more environmentally friendly than they actually are.

Another challenge is something known as Jevons' Paradox. In simple terms, when technology becomes more efficient, it often becomes cheaper and more accessible. This increased accessibility leads to higher demand, which can end up increasing overall energy use rather than reducing it. For example, as cloud services become more efficient, more people and businesses use them offsetting the energy savings.

Finally, there are regional differences to consider. In many developing countries, the priority is still expanding access to digital infrastructure and connectivity. While this is essential for growth and development, it often means that sustainability and proper e-waste management receive less attention. As a result, environmental impacts can be more severe in these regions.

4. Objectives of the Study

Efforts to make data centres and the broader IT sector more sustainable are guided by a range of practical goals. These goals come from research studies, industry guidelines, and real-world operational needs. While they may differ in focus, they all point toward the same outcome: reducing environmental impact while maintaining performance and keeping costs under control.

Core Research and Operational Goals

One of the main priorities is finding smarter ways to manage energy use without compromising performance. This includes developing systems that can automatically adjust how workloads are distributed across servers. Instead of running everything at full capacity all the time, tasks can be shifted or scheduled in ways that reduce unnecessary power consumption. Alongside this, improving cooling systems and integrating renewable energy sources are key areas of focus, since both play a major role in overall energy use.

Another important goal is creating clear and reliable ways to measure efficiency. Metrics like Power Usage Effectiveness (PUE), Carbon Usage Effectiveness (CUE), and Water Usage Effectiveness (WUE) are widely used to understand how efficiently a data centre operates. The challenge is not just using these metrics, but standardizing them so that organizations around the world can compare performance in a meaningful way and identify areas for improvement. On the technical side, there's also a strong focus on improving how hardware uses power in real time. Techniques such as Dynamic Voltage and Frequency Scaling (DVFS) allow systems to adjust their power usage based on current demand. For example, when a server isn't heavily loaded, it can run at a lower speed and consume less energy. This not only reduces electricity use but can also extend the lifespan of equipment.

More recently, researchers have been paying close attention to the environmental impact of artificial intelligence, especially large-scale models. A key objective is to better understand the difference between the energy used during training (when the model is built) and inference (when it's used in everyday applications). Since inference happens continuously and at scale, it often becomes the larger contributor over time. There's a growing need for better ways to measure and track this impact, including how user behavior influences energy demand.

New Approaches to Infrastructure and Design

Beyond improving existing systems, there's also interest in exploring entirely new ways of building and running data centres.

Some research looks at alternative architectures, such as high-altitude platforms essentially "floating" or airborne data centres. The idea is to take advantage of naturally cooler environments at high altitudes to reduce the need for energy-intensive cooling systems. While still experimental, these concepts show how far innovation in this space is reaching.

Another major focus is applying circular economy principles to IT infrastructure. Instead of the traditional "use and discard" approach, organizations are finding ways to extend the life of their equipment. This includes repairing, refurbishing, and reusing components wherever possible, as well as recycling materials at the end of their lifecycle. Large companies have already started adopting these practices to reduce both costs and environmental impact.

There's also ongoing work to standardize best practices across the industry. Initiatives like the EU Code of Conduct on Data Centre Energy Efficiency provide guidelines that help operators identify practical steps to improve efficiency. While these are often voluntary, they offer a shared framework that makes it easier for organizations to align their efforts.

Environmental and Economic Objectives

At a broader level, many of these efforts are tied to the goal of reducing the carbon footprint of the digital economy. Some researchers are even exploring whether IT systems could one day move beyond being carbon-neutral to becoming a net carbon sink, where they offset more emissions than they produce. Achieving this would require major advances in renewable energy use, efficiency, and system design.

Another important goal is energy security. For governments and large organizations, managing energy use efficiently isn't just about cost it's also about reducing dependence on limited or unstable energy sources. More efficient data centres can help ensure a more stable and resilient energy system overall.

At the same time, there's a strong emphasis on proving that sustainability makes financial sense. Many studies show that investing in energy-efficient technologies can lead to significant cost savings over time. Lower electricity bills, reduced cooling needs, and longer-lasting equipment all contribute to this. In many cases, the initial investment in green technologies can be recovered within three to five years, making it a practical as well as an environmental decision.

References

- Berl, A., Gelenbe, E., Di Girolamo, M., Giuliani, G., De Meer, H., Dang, M. Q., & Pentikousis, K. (2010). Energy-efficient cloud computing. *The Computer Journal*, 53(7), 1045–1051.
- Buyya, R., Beloglazov, A., & Abawajy, J. (2010). Energy-efficient management of data center resources for cloud computing: A vision, architectural elements, and open challenges. *Proceedings of the International Conference on Parallel and Distributed Processing Techniques and Applications*.
- European Commission. (2021). *EU Code of Conduct on Data Centre Energy Efficiency*. Brussels: European Union.
- Gartner, Inc. (2023). *Sustainable Data Centres and Green IT Trends Report*.
- Koomey, J. G. (2011). *Growth in data center electricity use 2005 to 2010*. Analytics Press.
- Murugesan, S. (2008). *Harnessing green IT: Principles and practices*. *IT Professional*, 10(1), 24–33.
- United Nations Environment Programme (UNEP). (2022). *Global E-Waste Monitor 2022*.
- U.S. Environmental Protection Agency. (2023). *Energy Star Program Requirements for Computers*.
- World Economic Forum. (2023). *Green Computing and Sustainable Digital Infrastructure Report*.
- Yadav, G., & Kumar, A. (2021). Green computing initiatives and sustainable data center management in India. *International Journal of Computer Applications*, 174(12), 15–21.
- [1] Murugesan, S. (2008). *Harnessing green IT: Principles and practices*. *IT Professional*, 10(1), 24–33.
- [2] Koomey, J. G. (2011). *Growth in data center electricity use 2005 to 2010*. Analytics Press.
- [3] World Economic Forum. (2023). *Green Computing and Sustainable Digital Infrastructure Report*.
- [4] United Nations Environment Programme (UNEP). (2022). *Global E-Waste Monitor 2022*.
- [5] European Commission. (2021). *EU Code of Conduct on Data Centre Energy Efficiency*. Brussels: European Union.

EDITORIAL TEAM

PROF. (DR.) BANSHI DHAR SINGH

Professor,
Ex. Dean & Head,
Faculty of Law,
University of Lucknow

DR. KALPESHKUMAR L GUPTA

Founder ProBono India, Legal Start-ups,
Law Teachers India

DR. SUDHANSHU CHANDRA

Assistant Professor, Manuu Law
School, Maulana Azad National Urdu
University (Central University),
Hyderabad

PROF. (DR.) SANJAY SINGH

Director
of IIMT College of Law

INTERNATIONAL EDITORIAL TEAM

PROF. DR. MARC OLIVER OPRESNIK

President and CEO
Opresnik Management Consulting
and Opresnik Business School

*PROF. DR . COMRADE AMB.
CHUKWUNONSO C
HARLES OFODUM ESQ*

Chancellor, ALSA University.
Legal Director for Nigeria, World
Association for Humanitarian Doctors

ABOUT LEX SCRIPTA JOURNAL

Lex Scripta Magazine is a premier peer-reviewed online and print journal dedicated to advancing scholarly research in law, policy, and social sciences. With the vision of promoting academic excellence and fostering a culture of intellectual exchange, the magazine provides a distinguished platform for academicians, researchers, legal professionals, and students to publish their original work and contribute to contemporary legal discourse.

Each submission undergoes a rigorous double-blind review process conducted by a panel of eminent national and international professors, ensuring the highest standards of quality and academic integrity. Lex Scripta not only encourages original and innovative research but also strives to bridge the gap between theoretical insights and real-world applications in the legal domain.

Contributors and editorial members receive global recognition through certificates and publication opportunities, while readers gain access to insightful, authoritative, and thought-provoking content across diverse areas of law and policy.

Now managed by Integrity Education India, Lex Scripta Magazine is committed to expanding its academic footprint through enhanced digital presence, global collaborations, and university partnerships. Upholding its ISSN identity, Lex Scripta continues to evolve as one of India's most trusted and respected journals in the field of legal research and education.

KEY FEATURES

- | **Scholarly Insights** – Access in-depth, peer-reviewed research articles written by distinguished academicians and legal experts.
- | **Global Perspectives** – Explore diverse viewpoints on law, policy, and governance from national and international scholars.
- | **Authentic Content** – Read verified and academically sound articles that uphold the highest standards of research quality.
- | **Knowledge Enhancement** – Stay updated with emerging trends, case studies, and policy developments across multiple legal domains.
- | **Easy Accessibility** – Enjoy seamless access to online editions and exclusive hardcover issues for academic and professional use.



CONNECT WITH US **9811 666 216**
7011 605 618

