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The Necessity for a Legal Framework to Regulate the Environmental Impact of Data Centers in Vietnam: International Experiences and Recommendations for Vietnam

Abstract

As Vietnam accelerates its digital transformation, data centers have quietly become essential infrastructure for the economy. However, behind this role lies a concerning reality: their development is running counter to the nation's environmental commitments, particularly the "net-zero" target for 2050. The core issue lies in a legal vacuum. Vietnam's current legal framework, particularly the 2020 Law on Environmental Protection, was designed for traditional industries and lacks specialized regulations to manage the unique impacts of data centers. Key internationally recognized environmental performance

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indicators, such as Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE), are almost entirely absent from normative documents. The lack of synchronization among environmental, energy, and technical infrastructure standards has created a fragmented legal environment, diminishing the effectiveness of state governance. An analysis of international experience reveals that advanced nations have proactively established effective legal frameworks. The European Union and Germany apply mandatory regulations with clear roadmaps for PUE and renewable energy adoption. The State of California (USA) utilizes a procedural mechanism, compelling investors to demonstrate and propose measures to mitigate environmental impacts from the initial permitting stage. Meanwhile, Singapore implements a comprehensive state management strategy through its Green Data Centre Roadmap. Drawing from these lessons, this paper proposes a system of synchronized solutions for Vietnam. The objective is not merely to "control" negative impacts, but to construct an intelligent legal corridor that transforms green standards into a genuine competitive advantage, enabling Vietnam's digital infrastructure to develop robustly and sustainably.

KEYWORDS: legal framework; environmental impact; Data Centers (DCs)

1 | Introduction

The global digital transformation process is profoundly restructuring the economy, while also posing an urgent demand for a sufficiently robust technical infrastructure[1]. In this context, data centers have emerged as a core, indispensable foundation. Functioning as hubs for the convergence, processing, and distribution of massive data resources, data centers are not only a prerequisite for the operation of cloud computing, artificial intelligence (AI), and the Internet of Things (IoT), but also for online public services. The relentless increase in demand for digital services is the primary driver for the construction and expansion of data centers, making them organically and inseparably integrated with the contemporary economic structure.[2]

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[1] Krzysztof Kaczmarek, Mirosław Karpiuk, Claudio Melchior, "A Holistic Approach to Cybersecurity and Data Protection in the Age of Artificial Intelligence and Big Data" *Prawo i Więź*, No. 3 (2024): 103-121.

[2] Dirk Turek, Peter Radgen, "Optimized Data Center Site Selection – Mesoclimatic Effects on Data Center Energy Consumption and Costs" *Energy Efficiency*, No. 3 (2021): 33.

However, alongside the outstanding benefits in economic growth and technological innovation, the operation of contemporary DCs is posing serious environmental challenges. The global energy consumption of DCs, estimated at 460 terawatt-hours (TWh) in 2022, is projected to exceed 1,000 TWh by 2026.[3] The massive-scale consumption of energy and water resources, coupled with significant greenhouse gas emissions, is placing heavy pressure on ecosystems and directly threatening efforts to achieve the Sustainable Development Goals (SDGs) on a global scale.

Within this general trend, Vietnam has identified digital transformation as a strategic driver for its new development phase, with major orientations outlined in the National Digital Transformation Program and Resolution No. 57-NQ/TW. This inevitably leads to the need to expand DC infrastructure to meet the data storage and processing demands of the digital economy. Here, a major policy paradox has emerged: the development of this essential digital infrastructure risks running counter to Vietnam's strong political commitment to sustainable development, particularly the goal of achieving net-zero emissions by 2050, as declared at COP26.[4]

This paradox becomes even more pronounced when considering the existing legal gaps. Although the 2020 Law on Environmental Protection and related documents have created a general regulatory framework, Vietnam still lacks a specialized, comprehensive, and effective legal corridor to regulate the specific environmental impacts of the DC sector. Technical regulations on energy efficiency, water use, emissions management, or environmental data reporting obligations for DC operators remain fragmented, not specifically defined, and lack sufficiently strong enforcement mechanisms. In practice, although some businesses have begun to integrate ESG (Environmental, Social, and Governance) factors into their reporting, the disclosure of quantitative data on the environmental impact of DCs remains limited, revealing a significant gap between commitment and practical action.[5]

From the issues outlined above, the study of establishing an effective legal framework to control and regulate the environmental impacts of DCs in Vietnam has become urgent. The authors aim to clarify the urgency of

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3 Minh-Thanh, "Xây dựng trung tâm dữ liệu phục vụ AI, nhu cầu tiêu thụ điện tại châu Á tăng vọt," *Nhịp sống kinh tế Việt Nam & Thế giới*, 7 May 2024.

4 Thu Cúc, "Việt Nam chủ động triển khai bài bản các cam kết tại COP26" *Báo điện tử Chính phủ* (baochinhphu.vn), 1 November 2023.

5 Huỳnh Diệu Ngân, "Hành trình ESG của Việt Nam: Thực trạng và giải pháp" *Tạp chí Kinh tế và Dự báo*, 19 June 2024.

this issue by: (1) Analyzing the current situation and assessing the level of environmental impact of DCs globally and in Vietnam; (2) Examining, comparing, and evaluating legal models, policies, and sustainable practices for DCs in several typical countries; (3) Based on this, proposing recommendations to improve Vietnam's legal framework, regulating DC activities in a manner consistent with green growth and sustainable development goals.

The paper employs the following research methods: (i) The legal analysis method is used to analyze regulations and policies in the world and in Vietnam related to the connection between DCs and environmental impact; (ii) the comparative methodology is used to study international legal regulations and policies on regulating the environmental impact of DCs, thereby learning from experiences for Vietnam; (iii) the case study method is used to provide practical illustrations, reinforcing the arguments and analyses presented in the research; and (iv) other scientific methods, including analysis and synthesis, will be integrated throughout the paper to clarify and strengthen the scientific arguments.

On that basis, this research is expected to contribute an in-depth legal perspective, supporting policy-making and shaping new management principles for DCs, a field that is still relatively new within the environmental and technology legal corridor in Vietnam.

2 | Overview of Data Centers and Environmental Impacts

2.1. Overview of Data Centers

2.1.1. Definition and Classification of Data Centers

Technically, according to the international standard ISO/IEC 22237-1:2021, a DC is understood as a specialized structure or group of structures designed to house, connect, and operate information technology and telecommunications equipment for the purpose of storing, processing, and transmitting data[6]. This definition emphasizes that a DC is an infrastructure

[6] International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), *ISO/IEC 22237-1:2021 Information Technology—Data Centre Facilities and Infrastructures—Part 1: General Concepts* (Geneva: ISO, 2021).

with a complex physical architecture, requiring compliance with specific technical conditions to ensure the operational capability of large-scale computing systems.

From a legal perspective, many countries have officially recognized DCs in their legal systems. For instance, United States federal law defines a DC as a facility containing electronic equipment for processing, storing, and transmitting digital information, while also requiring it to meet performance standards.[7] In Vietnam, the 2023 Law on Telecommunications defines a DC as a type of telecommunications facility, including station houses, computer systems, electrical equipment, and auxiliary infrastructure installed for processing, storing, and transmitting data.

From both these approaches, it can be understood that a DC is not just a space for servers, but a specific infrastructure structure, clearly regulated by law, and playing an essential role in managing, exploiting, and protecting data.

Regarding classification, DCs are currently divided according to various criteria, depending on the research objective or management requirements. This paper provides two approaches based on two common sets of criteria: (1) classification by ownership and (2) classification by technical standards.

Firstly, classification by ownership[8]:

1. Enterprise Data Center: Owned and operated by a single organization (a state agency or private enterprise) to serve its internal data storage and processing needs.
2. Colocation Data Center: A third party provides the infrastructure for businesses to rent space, power, and networking; the business still controls its own equipment and can configure it to its specific needs.
3. Cloud or Hyperscale Data Center: Operated by cloud computing service providers, offering processing resources, storage, and network services to users through a flexible and scalable virtualized environment.

7 'U.S.C. Title 42 – The Public Health and Welfate. https://www.govinfo.gov/content/pkg/USCODE-2016-title42/html/USCODE-2016-title42-chap152.htm. [accessed: 22.7.2025].

8 FS, "Comprehensive Guide to Data Center Classifications and Categories," FS. https://www.fs.com/sg/blog/comprehensive-guide-to-data-center-classifications-and-categories-11717.html. [accessed: 22.7.2025].

Secondly, classification by technical standard (Tier). Based on the Uptime Institute's evaluation system, DCs are divided into 4 levels from Tier I to Tier IV[9]:

1. Tier I: Basic infrastructure with no redundancy; suitable for systems that do not require continuous operation.
2. Tier II: Adds some redundant components, enhancing reliability compared to Tier I.
3. Tier III: Designed with multiple power and cooling sources, allowing for maintenance without service interruption; suitable for systems requiring high availability.
4. Tier IV: The highest level, ensuring continuous operation even during a severe incident; typically applied to critical systems, such as finance, healthcare, and national data.

The classification of DCs is not only of technical value, but also serves as a basis for developing appropriate legal regulations – from electrical safety and cybersecurity standards to obligations for environmental reporting and energy efficiency. This approach helps ensure transparency, controllability, and a sustainable development orientation for data infrastructure in the digital era.

2.1.2. Development Trends of Data Centers in the World and in Vietnam

In the context of the profound digital transformation occurring globally, DCs have become an essential infrastructure in the digital economy. No longer limited to data storage and processing, DCs today play a central role in operating foundational technologies such as cloud computing, AI, blockchain, and IoT. With this role, DCs are considered the "backbone" of the digital ecosystem[10] and a strategic asset in the technological develop-

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9 "Uptime Institute Tier Classification System" *Uptime Institute*, n.d. https://uptimeinstitute.com/tiers.

10 Emmanuel Igba, Kehinde Abiodun, Esther Ojoma Ali, "Building the Backbone of the Digital Economy and Financial Innovation through Strategic Investments in Data Centers" *International Journal of Innovative Science and Research Technology (IJISRT)*, No. 1 (2025): 332-348.

ment of many nations.[11] Consequently, many countries have identified DC development as a priority in their digital security and sustainable growth strategies. This is also a field of strategic competition among global technology corporations, not only for its economic potential but also for its long-term influence on data control and technological mastery.

As of 2024, there are over 11,000 active DCs globally, with a total market value of approximately 242.7 billion USD.[12] Among these, large-scale DCs account for over 35% of the market share and are primarily owned and operated by technology giants such as Amazon Web Services (AWS), Microsoft Azure, Google Cloud, Meta, Apple, Alibaba, and Tencent. It is projected that by 2032, the global DC market value could double to nearly 585 billion USD,[13] reflecting the rapid growth trend and increasing demand for efficient, secure, and sustainable digital infrastructure.

In the Southeast Asian region, Vietnam has emerged as a potential market with an impressive growth rate. In recent years, the DC market in Vietnam has achieved an average growth of 15-18% per year, surpassing the average for the Asia-Pacific region.[14] As of the first quarter of 2024, the country had 33 operational DCs, deployed by 49 licensed service providers, concentrated mainly in Hanoi and Ho Chi Minh City,[15] and is expected to expand strongly in the coming period.

It can be affirmed that Vietnam is entering a vibrant development phase for DC infrastructure, with many opportunities to leverage its digital economy potential. However, this is accompanied by significant challenges, particularly concerning the environment and energy. To effectively utilize its existing potential, there is a need for synchronous policies that promote green investment, improve the legal framework, and enhance public-private partnerships to ensure sustainable development and enhance national digital capacity in the digital era.

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11 Siemens Smart Infrastructure, "This Is the State of Play in the Global Data Centre Gold Rush" *World Economic Forum*, 22 April 2025.

12 "Data Center Market Size, Share & Trends|Growth Report [2032]" *Fortune Business Insights* (2025).

13 John Minnix, "215 Data Center Stats (June-2025)" *Brightlio*, (2025).

14 Mạnh Ninh, "Việt Nam đón làn sóng đầu tư trung tâm dữ liệu, tăng trưởng gần 18% mỗi năm" *Tạp chí Điện Tử Ứng Dụn* (2025).

15 Hồng Ánh, "Khai phá thị trường trung tâm dữ liệu" *Báo Nhân Dân điện tử*, 6 April 2025.

2.3. Environmental Impacts of Data Centers

2.3.1. Greenhouse Gas Emissions from Electricity Consumption

2.3.1.1. EMISSIONS DURING OPERATION

The continuous operation of DCs to meet the ever-increasing demands for data processing, storage, and exchange has led to massive electricity consumption. This, in turn, results in significant greenhouse gas emissions during DC operations,[16] becoming one of the factors exacerbating global climate change.

According to a report by the International Energy Agency (IEA), DCs currently consume approximately 1-1.5% of the total global electricity[17] – a figure comparable to, or even exceeding, the consumption of many countries.[18] It is projected that, by 2030, this consumption could more than double, reaching 945 TWh per year,[19] depending on the pace of technological development and the adoption of energy-saving solutions. Alarmingly, the majority of electricity-supplying DCs still comes from fossil fuels, such as coal, oil, and natural gas. These are the primary sources of CO_2 emissions during electricity generation,[20] thereby contributing to the greenhouse effect and global warming.

In a typical DC, the majority of electricity consumption is concentrated in two main component groups. First is the IT equipment, including servers, storage devices, and network infrastructure, which accounts for about 45-50% of total electricity consumption.[21] This is because these devices must operate continuously 24/7 to ensure the performance and stability of the entire system. Second is the cooling system, responsible for controlling temperature and maintaining safe operating conditions for the equipment,

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16 Dhanabalan Thangam et al., "Impact of Data Centers on Power Consumption, Climate Change, and Sustainability," [in:] *Computational Intelligence for Green Cloud Computing and Digital Waste Management* (Hershey, PA: IGI Global, 2024), 60-83.

17 Daniel Raphael Ejike Ewim et al., "Impact of Data Centers on Climate Change: A Review of Energy Efficient Strategies" *The Journal of Engineering and Exact Sciences*, No. 6 (2023): 6.

18 Renee Obringer et al., "The Overlooked Environmental Footprint of Increasing Internet Use" *Resources, Conservation and Recycling*, 167 (April 2021).

19 Siemens Smart Infrastructure, "This Is the State of Play in the Global Data Centre Gold Rush."

20 "Data Center Power Consumption: Challenges and Solutions" *Hivenet*, n.d.

21 Kazi Main Uddin Ahmed, Math H.J. Bollen, Manuel Alvarez, "A Review of Data Centers Energy Consumption and Reliability Modeling," *IEEE Access*, 9 (2021): 152536–63.

which consumes nearly 40% of the electricity,[22] especially during periods of high-intensity data processing. Notably, the rapid development of AI, particularly deep learning models and natural language processing (NLP), is placing significant pressure on the existing energy consumption structure. Unlike traditional computing tasks, modern AI models require a superior volume of computation, using specialized hardware such as GPUs or TPUs – which have a much higher power consumption density than conventional CPUs.[23]

According to an analysis by the IEA (2023), without the application of effective mitigation measures, global CO_2 emissions from DCs could increase to 300-500 million tons by 2035.[24] This not only threatens the world's climate goals, but also serves as a warning about the severe and difficult-to-remedy environmental consequences of the uncontrolled development trend of global DCs.

2.3.1.2. EMBODIED CARBON

In addition to emissions during the operational phase, another often-overlooked source with significant impact is the emissions throughout the equipment's lifecycle – known as embodied carbon. Processes such as raw material extraction, manufacturing of electronic components, equipment assembly, transportation, and infrastructure construction all consume large amounts of energy, the majority of which still comes from non-renewable sources.[25]

Notably, the short lifecycle of equipment is a direct factor increasing supply chain emissions. Under common operating conditions, servers and storage devices are typically replaced after a 3-5 year cycle to enhance

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22 Xiaojing Zhang et al., "Cooling Energy Consumption Investigation of Data Center IT Room with Vertical Placed Server" *Energy Procedia*, 105 (May 2017): 2047-2052.

23 Emma Strubell, Ananya Ganesh, Andrew McCallum, "Energy and Policy Considerations for Deep Learning in NLP," [in:] *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, ed. Anna Korhonen, David Traum, Lluís Màrquez (Florence: Association for Computational Linguistics, 2019).

24 Zachary Skidmore, "IEA: Data Center Energy Consumption Set to Double by 2030 to 945TWh" *Data Center Dynamics* (2025).

25 Dante Niewenhuis et al., "FootPrinter: Quantifying Data Center Carbon Footprint," [in:] *Companion of the 15th ACM/SPEC International Conference on Performance Engineering (ICPE '24 Companion)* (New York: Association for Computing Machinery, 2024), 189-195.

operational performance and minimize technical risks. This periodic replacement drives the need for new manufacturing and continuous supply chain operations, thereby further increasing emissions in the pre-operational stages.

Many recent studies indicate that supply chain emissions can account for up to 20-30% of the total lifecycle emissions of a DC.[26] This percentage tends to be even higher in countries with clean electricity grids, such as Norway, Sweden, or Canada, where operational emissions have been significantly reduced through renewable energy. In these cases, supply chain emissions can even surpass operational emissions.[27]

Thus, this reality shows that if the focus is solely on emissions during operation, while ignoring the pre-operational factors across the entire DC lifecycle, the assessment of environmental impact will be subjective and incomplete. This is an important consideration in policy planning related to the sustainable development commitments of the digital infrastructure sector.

2.3.2. E-Waste Generation

DCs are gradually becoming one of the largest and most concerning sources of electronic waste (e-waste) on a global scale. Unlike many traditional industries, DCs are characterized by continuous operation with high-intensity data processing requirements and a strong dependence on the pace of technological innovation.

In practice, each equipment update cycle in a DC typically lasts only 3 to 5 years[28] Consequently, a large amount of hardware – from servers and storage devices to network components – is replaced to ensure performance and compatibility with new infrastructure. This process rapidly increases the quantity of discarded technological equipment, leading to an ever-growing volume of e-waste.

26 Tuğana Aslan, Peter Holzapfel, Lutz Stobbe, Andreas Grimm, Nils F. Nissen, Matthias Finkbeiner, "Toward Climate Neutral Data Centers: Greenhouse Gas Inventory, Scenarios, and Strategies" *iScience*, No. 1 (2025).

27 Carole-Jean Wu et al., "Beyond Efficiency: Scaling AI Sustainably" *ArXiv preprint*, 22 June 2024.

28 Green Revolution Cooling, E-*Waste: Addressing a Growing Problem for Data Centers in 2022*, (2022).

According to statistics, DCs generate over 2 million tons of e-waste annually, accounting for approximately 4% of the total global e-waste.[29] Notably, the rapid and continuous development of AI, particularly large language models, is significantly increasing this pressure. The restructuring of infrastructure to meet the computational demands of AI is forcing DCs to shorten the replacement cycles for equipment like GPUs,[30] motherboards, and cooling systems, thereby exacerbating the e-waste problem in the digital infrastructure sector.

From an environmental standpoint, e-waste is a type of waste with high toxicity and the risk of long-term harm. Discarded electronic equipment often contains hazardous substances such as lead (Pb), mercury (Hg), cadmium (Cd), and other semiconductor compounds. If not properly treated, these substances can leach into soil, groundwater, or be released into the air, causing multi-level pollution and severely affecting ecosystems.[31] In particular, these heavy metals have long biological decomposition cycles, easily leading to bioaccumulation, food chain contamination, and widespread ecological exposure. This risk not only impacts the natural environment, but also threatens public health,[32] especially for vulnerable groups such as children, pregnant women, and the elderly, who are susceptible to long-term exposure to heavy metals.

Faced with the reality of rapidly increasing yet ineffectively controlled e-waste from DCs, it is particularly necessary to improve policies for managing equipment lifecycles, controlling environmental risks, and orienting the development of digital infrastructure towards sustainability, safety, and responsibility.

29 Data Centers and the Environment, 2019 Report on the State of the Green Data Center, 2020. https://www.supermicro.com/white_paper/DataCenters_and_theEnvironmentDec2019.pdf.

30 Russ Ernst, "Ticking Time Bomb: AI, Data Centers, and the Looming E-Waste Crisis" *Data Center Knowledge* (2025).

31 Devin N. Perkins et al., "E-Waste: A Global Hazard" *Annals of Global Health*, No. 4 (2014): 286-295.

32 Ibidem.

2.3.3. Pressure on Water Resources

Besides high electricity consumption and increasing e-waste volumes, DCs also exert significant pressure on water resources.[33] In DCs, water is primarily used in cooling systems to control the temperature of information technology equipment, such as servers, storage devices, and network equipment. Specifically, during continuous high-intensity operation, this equipment generates substantial heat. If the equipment is not cooled effectively, the rising temperature can reduce processing performance, increase the risk of equipment failure, and even cause system disruptions. Therefore, maintaining stable temperature conditions (typically ranging from 20 to 22 degrees Celsius) is a mandatory technical requirement to ensure the continuous, safe, and efficient operation of a DC.[34]

Two common cooling methods in DCs are air cooling and liquid cooling (Borgini, 2024). With the air cooling method, water is chilled to about 7-10°C by a chiller system and then used to cool the air in the server room.[35] This cold air is recirculated to maintain a stable temperature for the equipment. However, the heat exchange process causes water to evaporate, and most of it cannot be recovered, leading to significant water resource loss.[36] In the liquid cooling method, the system uses a dielectric fluid to absorb heat directly from the equipment. This method can be implemented by immersing the entire device in the fluid or by piping the fluid to high-heat points like CPUs and GPUs through a system of tubes. Despite technical differences, both forms result in evaporation and difficulty in reusing the liquid after cooling.[37] Thus, regardless of the technology applied, current cooling methods at DCs consume large amounts of water, posing a clear challenge to the efficient use of this resource during operation.

Currently, the water consumption of DCs is at an alarming scale. A medium-sized DC can use up to 110 million gallons of water per year, equivalent

33 James Riordon, "NASA Satellites Reveal Abrupt Drop in Global Freshwater Levels" *NASA Science: Earth*, 15 November 2024.

34 Justin Eure, "The World's AI Generators: Rethinking Water Usage in Data Centers to Build a More Sustainable Future" *Lenovo StoryHub*, 22 March 2024.

35 Kevin Heslin, "Ignore Data Center Water Consumption at Your Own Peril" *Uptime Institute Journal* (blog), 2016.

36 Dominic O'Donnell, "Data Center Water Usage Challenges and Sustainability" *Sensorex Liquid Analysis Technology*, 16 August 2022.

37 Julia Borgini, "Data Center Cooling Systems and Technologies and How They Work" *SearchDataCenter* (TechTarget), 2024.

to the annual domestic water consumption of about 1,000 households. For large-scale DCs, this figure can reach up to 5 million gallons per day, or about 1.8 billion gallons per year – equivalent to the water demand of a town with a population of 10,000 to 50,000 people.[38] Notably, the rapid development of A), especially LLMs, has been and is significantly increasing the demand for data processing at DCs.[39] This places considerable pressure on cooling systems, leading to ever-increasing water consumption during operation.

Faced with this situation, DCs are now ranked among the top ten commercial industries with the highest water consumption in the world.[40] Meanwhile, according to United Nations forecasts, by 2025, approximately 50% of the global population will be living in areas under severe water stress.[41] These data highlight the connection between DC operations and the water resource crisis, demanding timely and comprehensive policy solutions.

3 Legal Framework Regulating the Environmental Impact of Data Centers in Vietnam and Around the World

3.1. Legal Framework Regulating the Environmental Impact of Data Centers in Vietnam

Vietnam's legal framework regulating the environmental impacts of data centers is currently constituted by a multi-layered legal system that lacks integration. This system includes three main normative layers: (1) foundational principles on environmental protection, (2) regulations on energy management, and (3) technical infrastructure standards. However, the loose interaction and lack of synchronization among these layers have

38 Miguel Yañez-Barnuevo, "Data Centers and Water Consumption" *Environmental and Energy Study Institute (EESI)* 2025.

39 Heslin, "Ignore Data Center Water Consumption at Your Own Peril".

40 Taqi Joanne Emerson, James Johnson, "Data Centers and Water: From Scrutiny to Opportunity" *White & Case LLP*, 18 December 2024.

41 UNICEF, *Water Scarcity*, n.d.

created legal gray areas, weakening enforcement effectiveness and failing to address the inherent environmental impacts specific to the digital industry.

The foundational legal layer regulating the environmental impacts of data centers in Vietnam is formed mainly from the 2020 Law on Environmental Protection together with two pillar decrees, Decree 08/2022/ND-CP and Decree 06/2022/ND-CP. The Law and Decree 08/2022/ND-CP have established a modern management mechanism based on the principles of disclosure, transparency, and accountability, while laying the groundwork for the carbon market. Under the regulations, a data center must conduct an EIA if the project is classified into Group I (high risk of environmental impact, Clause 3 Article 28 of the 2020 Law on Environmental Protection) or Group II (at risk of impact, Clause 4 Article 28 of the 2020 Law on Environmental Protection). This classification is based on criteria stipulated in Decree 08/2022/ND-CP, in which decisive factors include: electricity consumption capacity, the scale of the backup generator system, the amount of water used for cooling, and whether the project site is near sensitive areas such as residential zones or water sources. Accordingly, data center projects with large scale and high risk of environmental impact must prepare an EIA report, in which they specify the legal basis and the degree of conformity with planning; assess the choice of technology and project components likely to cause adverse impacts; describe natural, socio-economic conditions and the suitability of the location; identify, assess, and forecast the main impacts and wastes generated in each project phase; in accordance with Article 32 of the 2020 Law on Environmental Protection. After the construction phase, these centers are required to obtain an Environmental Permit in order to operate under Article 32 of the 2020 Law on Environmental Protection, which explicitly stipulates discharge limits and obligations for monitoring and periodic reporting. However, in practice after more than one year of implementing the 2020 Law on Environmental Protection, as recorded by experts, the lack of detailed guidance and the contradictions in certain provisions are major barriers to enterprises' legal compliance (CEBID, 2023). It is precisely here that the first conceptual incompatibility appears.[42] The environmental law system was built based on the model of traditional industries, where "pollutants are defined as tangible wastes such as air emissions (SOx, NOx), industrial wastewater,

42 Trung tâm Đổi mới sáng tạo vì Bình đẳng và Phát triển (CEBID), *Những vướng mắc qua thực tiễn 1 năm triển khai Luật Bảo vệ Môi Trường 2020*, 2023.

or hazardous solid waste." Meanwhile, the largest environmental impacts of a data center are of a different nature: (1) massive energy consumption from the national power grid and (2) the emission of excess thermal energy into the environment. The 2020 Law on Environmental Protection and its guiding documents are almost entirely "silent" on the core environmental performance indicators of the global DC industry, such as PUE, WUE, or ERR.[43] Under this law, enterprises must provide and disclose information on pollutants, wastes, environmental impact assessment reports, and ecosystems via the national information system or electronic portals, ensuring public accessibility. Therefore, a data center can fully comply with EIA reporting obligations by declaring emissions from backup generators or the handling of used batteries, yet remain completely outside the law's control with respect to the operation that consumes megawatts of electricity every hour. This creates a paradox in which the law strictly manages peripheral impacts but entirely leaves the core impact open. In addition, Clause 1 Article 6 of Decree 06/2022/ND-CP concretizes Articles 91 and 92 of the Law on Environmental Protection by stipulating that facilities emitting from 3,000 tons of CO_2 equivalent per year or consuming from 1,000 TOE per year, including data centers, must conduct greenhouse-gas inventory, develop emission-reduction plans, and report energy-efficiency indicators (such as PUE). This has shifted large-scale data centers from "voluntary" to "mandatory obligations." When exceeding 3,000 tons of CO_2 equivalent per year or 1,000 TOE per year, enterprises must inventory greenhouse gases, prepare reduction plans, and report energy-efficiency indicators. This requires installing metering down to the equipment level to calculate reliable PUE, integrating electricity-water-fuel data into the management system, and determining an emissions baseline and annual reduction targets.

The second legal layer, shaped by the Law on Economical and Efficient Use of Energy 2010, establishes principles for energy management intertwined with energy security strategies and environmental protection. It mandates that key energy-consuming facilities develop annual and five-year plans, conduct periodic energy audits, and comply with technical standards on energy efficiency, thereby approaching data centers from the perspective of a "key energy-consuming facility." Under this lens, data centers – with

43 Daniel Raphael Ejike Ewim et al., "Impact of Data Centers on Climate Change: A Review of Energy Efficient Strategies" *The Journal of Engineering and Exact Sciences*, No. 6 (2023): 16397–01e.

their inherent continuous large-scale electricity consumption – naturally fall under stringent regulatory oversight. This management logic, while effective for factories with relatively stable production cycles, proves outdated and ill-suited when confronting the operational essence of a data center. The load of a data center is not static, but fluctuates continuously on a millisecond basis, contingent upon traffic volume and computational tasks. Conducting periodic energy audits is akin to assessing a marathon runner's health by measuring their heart rate only once throughout the entire training regimen. It yields a static, obsolete snapshot that utterly fails to capture actual energy efficiency and cannot foster real-time optimization behaviors. Moreover, the Law emphasizes energy labeling for individual devices but lacks a mechanism to measure and standardize the overall performance of a complex system. This constitutes the gap that precludes the PUE (Power Usage Effectiveness) metric – despite being the industry's gold standard – from becoming a mandatory legal requirement in Vietnam. Concurrently, Decision 500/QD-TTg delineates the national power source structure, prioritizing renewable energy, curtailing coal-fired thermal power, and fostering synchronous transmission grid development, thereby positioning data centers within the category of critical loads directly impacted by grid overload scenarios. Supply reliability thus directly governs PUE and the frequency of backup generator operations, while the proportion of renewable electricity and water infrastructure conditions influence carbon intensity and WUE (Water Usage Effectiveness), guiding site selection near priority transmission corridors and with effective electronic waste management protocols.

Within the specialized legal tier concerning technical infrastructure standards, the prevailing key instrument is Circular 23/2022/TT-BTTTT, which mandates data centers to adhere to rigorous standards such as TCVN 9250:2021 or ANSI/TIA-942 (Clause 1, Article 4), to safeguard the quality and security of the national digital infrastructure. However, upon deeper scrutiny, a notable divergence emerges between the environmental protection orientation and the practical application of the technical standards framework: standards like TIA-942 or the Uptime Institute's Tier classification system focus almost exclusively on reliability and uptime, compelling data centers to implement multi-layered redundant power and cooling systems. Maintaining these redundant systems, often at low loads for failover readiness, results in wasteful electricity consumption, elevating PUE and diminishing energy efficiency. The paradox lies in the fact that a data center may attain Tier IV certification for reliability while concurrently operating inefficiently from an energy standpoint. Furthermore, Circular 23 merely "encourages" existing data centers to retrofit for environmental compliance, inadvertently permitting legacy facilities to persist in inefficient operations without substantive legal compulsion for reform. In contrast, the Government's and Ministry of Information and Communications' digital infrastructure strategies – particularly Decision 1132/QD-TTg and the Digital Infrastructure Development Framework – orient toward establishing "green data centers," aligned with international standards and technological planning, even preliminarily referencing a PUE threshold of approximately 1.4 as a benchmark for environmentally friendly data centers. This duality indicates that, in terms of policy direction, Vietnam has articulated objectives to integrate digital infrastructure development with environmental sustainability; however, in practice, the extant technical standards framework remains biased toward operational reliability, without robust integration of environmental metrics such as PUE, WUE, emissions from backup generators, or electronic waste management. Consequently, adjustments are imperative to reconcile these dual objectives, embedding environmental requirements within infrastructure technical standards to ensure both high reliability and the advancement of sustainable data center development in Vietnam.

It is evident that the limitations within the environmental legal framework for data centers do not manifest in isolation. Rather, they form a tightly interwoven chain of issues, wherein a legal impediment precipitates practical challenges for enterprises and regulatory authorities alike. At the core, the root cause is the absence of specific provisions. Pivotal statutes such as the Environmental Protection Law 2020 remain overly generic, devoid of tailored clauses for the data center sector. In the absence of explicit regulations, enterprises are left uncertain about precise compliance obligations. This compels them to navigate between two suboptimal paths: either incurring substantial expenditures on premium technologies merely for precautionary assurance, or risking legal infractions. Both options impose onerous financial burdens, particularly on small and medium-sized enterprises. Secondarily, the complexity escalates as Vietnam's regulations have yet to formally incorporate globally prevalent international standards, such as the PUE metric. Without an officially endorsed common benchmark, enterprises grapple with technology selection and encounter difficulties in benchmarking and evaluating their operational efficacy against peers. This also hampers state agencies in conducting inspections and oversight. Ultimately, these intertwined issues culminate in a tangible predicament: a shortage of human resources. With ambiguous legislation and unharmonized technical standards, the formulation of comprehensive training curricula becomes infeasible. How can one cultivate an expert in data center environmental management when the requisite standards and criteria for such roles remain ill-defined? This dearth of specialists not only decelerates appraisal and licensing procedures, but also exacerbates the challenges in sustainably operating data centers.

In essence, this can be conceptualized as a chain: non-specific legislation engenders elevated compliance costs and a paucity of standards, which in turn precipitates a shortfall in skilled personnel. To foster sustainable development in the data center industry, a holistic resolution of this interconnected chain is essential, commencing with the refinement of the legal framework in a more precise and pragmatic manner.

3.2. Legal Regulations and Policies Regulating the Environmental Impact of Data Centers Around the World

3.2.1. Regarding the Legal Framework

Globally, many developed countries and regions have long recognized the importance of controlling the environmental impact of data centers (DCs) and have proactively built legal frameworks and policies appropriate to their contexts. Although each has a different approach regarding the level of compulsion and enforcement methods, the common goal is to develop a more sustainable, efficient, and transparent digital infrastructure.

In Europe, the European Union (EU) is one of the leading regions with a multi-layered legal and climate policy system. Prominent among these are the EU Climate Law and the Energy Efficiency Directive (EED). The EU Climate Law, effective since July 2021, has transformed the goals of the European Green Deal into legally binding obligations, setting a commitment to achieve net-zero emissions by 2050 and to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. To operationalize these targets, the EU has implemented the "Fit for 55" package, within which the Energy Efficiency Directive (EED) (EU 2023/1791) plays a pivotal role.

The new Energy Efficiency Directive (EED) represents a major reform, fully replacing the previous directive with more stringent provisions on energy efficiency, particularly for data centres. Under the new regulations, data centres with an installed IT power capacity of 500 kW or above are required to collect, analyse, and publicly disclose data on PUE, WUE, environmental footprint, and waste heat reuse potential (Article 12(1) EED, 2023). This data must be disclosed for the first time in May 2024 and updated annually, enabling the EU to develop concrete sustainability benchmarks for the entire region. In addition, data centres with a total energy input exceeding 1 MW are required to utilise or recover waste heat, except where such utilisation or recovery is technically or economically infeasible (Article 26(6), EED 2023). These regulatory provisions not only promote transparency and strengthen environmental accountability, but also support the EU's strategic objectives of reducing greenhouse-gas emissions and enhancing energy efficiency.

In Germany, the Federal Energy Efficiency Act (EnEfG 2023) is a prime example of domesticating EU directives, while setting very high standards for the DC industry. This law specifies targets for reducing final and primary energy consumption by 2030 and 2045. For DCs, the law requires them to achieve a maximum PUE of 1.5 from 2027 and 1.3 from 2030 (Article 11(1) EnEfG 2023), with new centers (operational from July 2026) required to achieve a PUE not exceeding 1.2 (Article 11(2) EnEfG 2023). The law also mandates that DCs use a minimum of 50% renewable energy from 2024 and 100% from 2027 (Article 11(3) EnEfG 2023), establish an energy management system, mandate waste heat reuse, and publicly disclose detailed operational data into a common European database. Other mandatory obligations include the establishment of an energy management system (for example, in accordance with ISO 50001), compulsory waste-heat reuse, and the public disclosure of detailed operational data into the EU-wide common database (applicable to data centres with a capacity of 300 kW or above). These provisions are strictly supervised, with severe penalties that may reach up to 100,000 euros in cases of non-compliance. Beyond data centres, the legislation also imposes energy-saving obligations on large enterprises and requires public authorities to take the lead and set an example.

In the United States, instead of a single federal statute, environmental regulation of data centres is primarily implemented at the state level, with the California Environmental Quality Act (CEQA) serving as the most prominent and stringent example. CEQA is not a regulatory code that directly prescribes metrics such as PUE or WUE; rather, it is a procedural statute requiring developers to analyse, disclose, and mitigate environmental impacts as a condition for project approval. When a new data centre is proposed, the process begins by determining whether it qualifies as a "project" within the meaning of the statute. Under §21065 of the Public Resources Code (PRC), the term 'project' is defined broadly to include any activity undertaken by a private entity that requires approval from a public agency; a data centre therefore clearly falls within this scope. Subsequently, the lead agency must conduct an Initial Study pursuant to §15063 of the CEQA Guidelines to determine whether the project may have a "significant effect on the environment." This concept is defined in PRC §21068 as a substantial, or potentially substantial, adverse change in the environment. For a data centre, factors such as massive energy demand, the use of millions of gallons of water for cooling, and associated greenhouse-gas emissions will almost certainly be examined as potential significant impacts. If evidence indicates that a significant impact may occur, PRC §21002.1 requires the public agency to adopt feasible mitigation measures to reduce such impacts. A data-centre developer cannot merely report its high energy consumption; it must propose concrete mitigation strategies, such as: (1) committing to achieve an exceptionally low PUE through advanced design; (2) utilising recycled water or high-efficiency closed-loop cooling systems to reduce water consumption; and (3) entering into long-term Power Purchase Agreements (PPAs) with renewable-energy providers.

3.2.2. Regarding Regulatory and Incentive Policies

In addition to mandatory legal regulations, many countries and regions also implement regulatory and incentive policies to promote the development of sustainable DCs.

In Europe, the EU encourages voluntary initiatives, such as the EU Code of Conduct for Data Centres, which encourages operators to adopt best practices in energy saving, PUE transparency, and the integration of green technology solutions.

In Asia, Singapore stands out as a model of proactive and strategic state management. Following a moratorium on new DC permits from 2019 to 2022, the island nation announced the Green DC Roadmap. This roadmap sets comprehensive goals such as a PUE below 1.3 and a WUE below 2.0 m^3/MWh within 10 years,[44] while also promoting technological innovation (Tropical DC Standard, advanced cooling technologies) and the

44 Infocomm Media Development Authority, *Driving a Greener Digital Future: Singapore's Green Data Centre Roadmap* (Singapore, 2024).

use of green energy to license at least 300 MW of new capacity for projects using low-carbon energy.

These advanced policies and legal frameworks show that the EU, Germany, Singapore, and the United States not only set stringent standards for energy efficiency and the environment for DCs, but also flexibly combine mandatory regulations with incentive mechanisms, creating strong momentum for a green transition in the digital infrastructure sector. These are valuable experiences that Vietnam can reference in the process of building a legal framework for sustainable DC management.

4 | Policy Solutions and Recommendations for Perfecting Vietnamese Law

Based on the analysis of experiences from advanced countries, we propose a system of seven synchronized solutions with tight linkages, aimed at shaping a sustainable digital future for Vietnam.

Firstly, prioritize the development and promulgation of a set of National Standards for sustainable data centers, with specific objectives and a mandatory roadmap. This is a foundational solution that plays the role of establishing a common benchmark and minimum technical requirements for the entire industry. The lack of a clear benchmark will lead to uneven development, where investors may choose to sacrifice environmental standards to maximize short-term profits. Experience from Germany with EnEfG and Singapore with the Sustainable Data Centre Roadmap has demonstrated that regulations of an incentive nature are often not strong enough to create system-level change. Therefore, Vietnam's standards need to be mandatory and developed in a scientific manner, focusing on core performance indicators that are internationally recognized. Accordingly, the Ministry of Science and Technology, assigning the Directorate for Standards, Metrology and Quality, shall be responsible for drafting.

Specifically, the standards need to clearly stipulate measurement methods and mandatory performance thresholds, according to a roadmap, for important indicators such as: Power Usage Effectiveness, Water Usage Effectiveness, Carbon Usage Effectiveness, and the Ratio of Renewable Energy Use. The implementation roadmap can be divided into stages, for example: the initial stage focuses on requiring the installation of measurement equipment and data reporting; the next stage sets initial performance thresholds; and the final stage tightens requirements, such as new data centers built from 2028 must achieve PUE ≤ 1.3 and 50% of energy consumed must come from renewable sources. From there, mandatory benchmarks will help gradually reduce PUE and WUE, thereby lowering operating costs and reducing pressure on local electricity and water. Next, increasing the share of renewable energy leads to a reduction in carbon emission intensity and opens up opportunities to access green credit. At the same time, standardized measurement and reporting data enhance transparency, helping regulatory agencies conduct effective ex-post review and investors accurately compare performance. On that basis, the momentum for innovation in cooling technology and heat recovery is activated, improving energy efficiency across the entire system, while limiting uneven development among localities and strengthening confidence in a stable policy orientation.

Secondly, integrate data center management regulations into the existing legal system to ensure consistency and feasibility. Building an entirely new law dedicated solely to data centers may take substantial time and resources, while this industry is developing at a very rapid pace. Therefore, a more practical and effective approach is to integrate specific regulations into existing specialized laws, similar to how California (United States) uses CEQA to manage large technology projects. To establish a comprehensive and effective legal corridor for managing the development of data centers, we propose a two-step legal approach. The foundational step is to amend Decree No. 08/2022/ND-CP to officially identify "Investment and operation projects for data centers with a designed capacity of 500 kW or more" as Group II investment projects, subject to the mandatory requirement of preparing an environmental impact assessment report. However, to make the assessment deep and substantive, the next core step is to directly amend Article 32 of the 2020 Law on Environmental Protection. Accordingly, the Law needs to add a new clause, stipulating that the EIA report for this type of project must include specific, mandatory content. These requirements must range from an in-depth analysis of PUE and WUE, quantitative assessment of impacts on the power grid infrastructure, development of a comprehensive lifecycle management plan for electronic waste, to the requirement to have a feasible technical plan for waste-heat recovery and reuse. The combination of these two amendments will create a tight legal framework that not only clearly defines responsibilities but also sets out specific technical standards, ensuring that the nation's critical digital infrastructure is developed robustly while remaining in harmony with strategic goals on energy security and sustainable environmental protection.

In parallel with that is the amendment of Decree No. 21/2011/ND-CP to add a new criterion, thereby identifying "Data centers with energy consumption from 500 TOE/year or more" as key energy-using facilities. Instead of having to create a new management mechanism, this small change will automatically trigger a series of legal obligations already clearly stipulated in the Law on Economical and Efficient Use of Energy. Specifically, data centers in this category will by default have to comply with mandatory requirements such as conducting energy audits every 03 years (under Article 34), developing and implementing detailed annual and 05-year energy management plans (under Article 34), as well as appointing an energy manager with professional certification (under Article 35). This approach helps to effectively leverage the existing law enforcement apparatus, ensuring that critical digital infrastructure is closely supervised, in sync with the overall picture of energy security and sustainable national development.

Thirdly, establish a mechanism for monitoring, reporting, and transparency of information. Regulations will only remain on paper if there is no effective monitoring and enforcement mechanism. The lesson from the EU's EED shows the importance of data collection and public disclosure. Vietnam needs to build a mandatory periodic reporting system whereby all data centers within the scope of regulation are obliged to collect and submit annual reports on key environmental performance indicators that have been stipulated in the National Standards. To ensure accuracy and objectivity, reported data needs to be verified through a third party, namely independent auditing entities with expertise in energy and the environment. Audit results must be sent simultaneously to the state management agency and be published in summary. Based on the data collected, a national database on data center performance needs to be established. After anonymizing sensitive business information, aggregated data on industry-average PUE, WUE, renewable energy usage ratio, etc., needs to be made public. Accordingly, the Ministry of Industry and Trade is responsible for guiding the reporting process for energy indicators, organizing periodic energy audits, and integrating results into the management of key energy-using facilities. The Ministry of Natural Resources and Environment presides over receiving and conducting ex-post review of environmental indicators, integrating them into EIA dossiers and post-licensing management.

The Ministry of Information and Communications builds and operates the national digital platform on data center performance, ensuring information security and data connectivity with relevant ministries and sectors. This transparency helps state regulators formulate evidence-based policies, facilitates investors and customers in comparing and selecting sustainable service providers, and at the same time creates healthy competitive pressure for underperforming enterprises to continuously improve their environmental performance.

Fourthly, implement financial and market incentives to create momentum for the green transition. Alongside mandatory regulations ("the stick"), preferential policies ("the carrot") play a pivotal role in creating economic motivation for enterprises to invest in sustainable technologies, which often involve high initial costs. Vietnam needs to design a diverse incentive package, which the authors propose to include:

1. Tax and credit incentives: Apply preferential tax rates (reductions in corporate income tax during some initial years, exemptions/reductions of import duties on high-efficiency green technology equipment) for data centers that meet or exceed national standards. At the same time, facilitate access for green data center projects to green credit sources with preferential interest rates from commercial banks and development investment funds.
2. Market and procedural incentives: Create favorable conditions for green data centers to sign direct power purchase agreements with renewable energy suppliers. This is a mutually beneficial mechanism, helping data centers ensure a clean and stable energy supply at competitive prices, while renewable energy developers gain large and long-term customers. In addition, a priority mechanism in administrative procedures can be applied, allowing shortened review and construction permitting times for data center projects with clear commitments to sustainable development. Experience from Singapore shows that projects meeting green standards are prioritized in the allocation of new capacity quotas, demonstrating the effectiveness of non-financial incentives in promoting the green transition of the digital infrastructure sector. This approach increases market certainty and the ability to mobilize capital, thanks to direct power purchase agreements that lock in clean energy costs at competitive and long-term levels. At the same time, procedural prioritization shortens approval times and reduces implementation

risks, thereby accelerating project timelines and attracting high-quality investment flows.

3. In particular, attention should be paid to transition costs for existing data centers. Upgrading older data centers to meet new standards on energy and environmental efficiency will incur significant costs, raising the question of who will bear them. To address this issue, in addition to the aforementioned tax and credit incentives, the State should consider establishing green transition support funds or co-financing programs, in which the state budget, international organizations, and enterprises jointly share upgrade costs. This mechanism not only helps reduce the financial burden on businesses, but also promotes a synchronized transition, avoiding disparities in technological level and environmental performance between new and operating data centers, ensuring that the entire sector advances together toward the goal of sustainable development.

Fifthly, promote the reuse of waste heat, turning waste into a resource. Waste heat released from thousands of servers in data centers is a vast resource, yet most of it is currently being wasted. Drawing on mandatory regulations from Germany and RU, Vietnam needs a strategic approach to harness this heat source effectively. Accordingly, the Ministry of Natural Resources and Environment will lead the mandate to include a heat-reuse plan in EIA reports for DCs with a capacity above 1 MW, issue technical guidelines, define cases of exemption where reuse is not technically or economically feasible, and coordinate with localities to integrate this into sustainable urban planning. At the same time, the Ministry of Planning and Investment will adjust the licensing process, prioritize DCs located near residential areas, high-tech agricultural greenhouses, or industrial parks, issue priority licensing criteria, require heat-reuse commitments in investment dossiers, and support the mobilization of PPP financing from organizations such as the ADB. The Ministry of Industry and Trade will provide technical support, develop standards for heat-recovery systems, incorporate them into the Law on Economical and Efficient Use of Energy, coordinate with energy suppliers to assess potential, and encourage the use of renewable energy. In addition, urban and industrial spatial planning should prioritize licensing DCs near areas with heat demand—such as residential zones for hot-water supply, greenhouses, aquaculture, or factories requiring heat for drying and steaming. Incentive or mandatory mechanisms for large-capacity DCs must include a plan for heat recovery and reuse, except where infeasible. PPP models can be deployed to build heat distribution networks in which DCs supply heat and end-users are customers, thereby reducing energy costs, creating economic and environmental symbiosis, and contributing to national greenhouse-gas reduction goals. This serves specific objectives such as reducing annual greenhouse-gas emissions, supplying waste heat for applications like residential heating, agricultural greenhouses, or industrial processes, and lowering energy costs for consumers by 15–20%. From there, a large number of green jobs can be created (in operating and maintaining heat systems), ESG indicators of Vietnam's DC sector can be enhanced in line with global trends, and the sustainability of digital infrastructure can be increased.

Sixthly, make strategic investments in research, development, and training of high-quality human resources. To keep pace with global technology trends and optimize the operational efficiency of data centers in a hot and humid climate, the Ministry of Science and Technology will preside over research, development, and sandbox testing programs for advanced data center technologies, focusing on liquid-cooling systems that are more efficient than air cooling, on-site renewable energy integration and storage solutions, and AI-based real-time energy management software. The Ministry will issue a policy framework to support PPP and concessional financing for green technologies, fund sandboxes at the Saigon Hi-Tech Park, and coordinate with enterprises and international organizations such as Singapore (through IMDA or VSIP) for technology transfer and curriculum development. In parallel, develop formal training programs and internationally recognized professional certifications on the design, construction, and operation of green data centers, integrate sustainable data center content into engineering curricula, grant certifications such as Certified Data Centre Professional, and organize short-term courses with Singaporean partners via GITEX Asia 2025. The expectation is to optimize operating costs and improve energy efficiency of data centers; increase attraction of R&D investment; expand the scale and quality of green data centers; promote the formation of sustainable jobs in the digital infrastructure sector; and at the same time reduce the intensity of greenhouse gas emissions, contributing to the realization of the long-term goal of carbon neutrality.

Seventhly, shift the control focus to the early stage of the project, requiring sustainability commitments right from the investment licensing phase. Instead of focusing only on controlling environmental impacts during the operational phase or end of life, Vietnam should shift the focus to the early stage of the project lifecycle. Specifically, the State should require large-scale data centers to commit to targets for energy efficiency, water use, greenhouse gas emissions, and green technology solutions from the time of project preparation and investment licensing application. Experience from CEQA shows that data center developers are required to present detailed commitments on PUE, use of recycled water, renewable power purchase agreements, and other environmental mitigation measures before being granted a construction permit. This helps to screen out unsustainable projects from the outset, while creating incentives for enterprises to proactively invest in green technology and make environmental commitments transparent to the community and regulatory agencies. Therefore, in the process of improving the legal framework, Vietnam should clearly stipulate that all large data center projects must have a detailed environmental commitment document, which is appraised and monitored throughout the project lifecycle. The authors propose that, during appraisal and issuance of the investment registration certificate, large-scale data center projects be required to submit a detailed and legally binding "Environmental Commitment Statement." This statement must clearly present: (i) Projected performance indicators (PUE, WUE); (ii) Plan for the use of renewable energy; (iii) Green technology solutions to be applied; (iv) Plan for lifecycle management of equipment. These commitments will not only be reference documents, but will also become an inseparable part of the investment license and the basis for competent authorities to supervise and conduct post-inspection throughout the project's lifecycle. Requiring a strong commitment from the outset will help effectively screen out investors who lack capacity or goodwill, while enhancing corporate accountability before the law and the community, consistent with the global trend of sustainable governance (ESG). To enhance the sustainability of data centers in Vietnam, the Ministry of Planning and Investment will preside over appraisal and issuance of the investment registration certificate, requiring large data center projects to submit the "Environmental Commitment Statement." In addition, the Ministry of Natural Resources and Environment will appraise the "Commitment" in the EIA report under Decree 08/2022/ND-CP, issue technical guidance for assessing commitments on greenhouse gas reduction, recycled-water use, and mitigation measures, refuse to license projects that fail to meet standards, and build transparent reporting systems for post-inspection, ensuring compliance from project preparation to operation. This, in turn, screens and eliminates unsustainable projects, thereby reducing environmental risks and increasing the proportion of green data centers in the system. At the same time, it attracts high-quality capital in the medium term, promotes green investment from institutional investors and financial institutions, enhances transparency of commitments to the community, and consolidates social confidence in a sustainable development orientation.

5 Conclusion

The 21st century has placed Vietnam on a strong digitalization development trajectory, where digital infrastructure, with DCs as its core, has become an indispensable lifeline for economic prosperity and social progress. However, behind this role as a growth driver lies a structural environmental and energy security challenge. DCs, with their massive consumption of energy and water resources, pose a difficult problem: how to expand digital infrastructure capacity without paying the price of environmental degradation and increased pressure on the national power grid. The authors affirm that a passive approach, waiting for the market to self-regulate, is no longer appropriate. Vietnam is at a crucial crossroads, where proactively creating a comprehensive, effective, and visionary legal framework will determine the nation's sustainable development trajectory for decades to come.

Analysis of international experience has provided invaluable lessons, showing a diversity of approaches, but all sharing a common goal. From the European model, the lesson on the power of mandatory regulations, with clear roadmaps and a transparent monitoring and reporting system, has been proven to be a pillar for creating synchronous change on a large scale. Meanwhile, the experience from California, USA, shows the effectiveness of a procedural legal mechanism, where the burden of proof and proposing solutions to mitigate environmental impacts is shifted to the developer, thereby indirectly promoting high standards from the initial stages of a project. And from Singapore, a model of strategic state management has emerged clearly, harmoniously combining the setting of strict standards with strong investment and support for innovation to turn challenges into competitive advantages. In summary, there is no single formula for all, but a successful framework for Vietnam must be a smart combination of elements: mandatory requirements, flexibility in implementation, and the enabling role of the state.

On that basis, the research has proposed a synchronized system of solutions comprising seven main pillars. The foundation of this system is the development of a mandatory set of National Standards and the integration of DC management regulations into the current legal system. A mechanism for monitoring, reporting, and information transparency. A system of diverse incentive policies. Looking to the future, promoting the reuse of waste heat and strategic investment in research, development, and human resource training will help Vietnam master technology and optimize resources. Finally, shifting the control focus to the early stages of the project, requiring sustainability commitments right from the licensing phase, will be a strategic preventive step, ensuring sustainable development from the roots.

Building a legal framework for sustainable DCs is not only an environmental obligation, but also a strategic investment for the future and for enhancing national competitiveness. A clear, transparent, and highly predictable legal corridor will attract leading global technology investors, who increasingly value standards on environment, society, and governance (ESG). By decisively and synchronously implementing the proposed solutions, Vietnam will not only solve its internal energy and environmental problems but can also assert its position as a leading regional digital hub – a hub that is not only technologically powerful but also a pioneer in sustainable development.

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