Climate Action
Against Disinformation

roots

# Data Centers and its environmental impacts in Brazil: A brief overview

## An extension of the research: Who Bears the Weight of the Cloud?

www.poweredbyroots.org
hello@poweredbyroots.org

www.caad.info
contact@caad.info

# TABLE OF CONTENTS

Written by Marilia Papaléo Gagliardi

Peer reviewed by Phil Newell

Edited by Sandra Ata and María Rosario Coll

November 2025

# Abstract

In order to delve into the environmental impacts of data centres in Brazil, it is important to understand how they operate and how they are constructed. To this end, a literature review has been conducted to evaluate the sustainability promises made in data centre projects, the amount of space required to build these infrastructures, the territories in which they are located, the materials needed for their construction and their origins, the environmental impacts generated by electricity consumption, the expenditure of raw materials, what the announced renewable energies consist of and their effects, and what the social gains would be in terms of promised labours, especially considering the Brazilian scenario.

.

# What are Hyperscale Data Centers?

The concept of data centres is not new, having existed since 1990 to describe physical facilities for housing computer systems and their components, which require "power supplies with the capacity to provide backup power, necessary communications equipment and redundant communications cabling systems, air conditioning, fire suppression and physical security devices for personnel entrances" (Balodis 2012).

This definition therefore applies to various types of data processing centres. However, this research focuses on hyperscale data centres, which are large-scale facilities designed to provide robust and scalable computing, storage, and networking resources. According to the most widely recognised definition, they have an architecture optimised for extreme scalability and are designed to support large-scale workloads, featuring optimised network infrastructure, simplified connectivity, and minimised latency (POWELL; SMALLEY, 2024). Due to their size, they have the greatest environmental and social impact, having impact on the space they occupy, the energy they consume, the waste they generate and the cooling capacity required in their surroundings.

A question that arises in this context is why this type of infrastructure is needed and why there is interest in its construction. The truth is that this is due to the growing market for artificial intelligence.

These facilities are widely used by cloud service providers (CSPs) and other large companies for various purposes, including artificial intelligence (AI), automation, data analysis, storage, and other forms of big data computing (POWELL; SMALLEY, 2024). Unlike other technologies, the quality of the product generated by AI no longer requires data processing to be close to where the product is delivered, but only that there is a large amount of electricity available to supply the massive processing of information. Consequently, energy availability has now become the most critical factor in choosing an installation location (RONG; ZHANG; XIAO; LI; HU, 2016).

In this new scenario, Brazil emerges as a possibility for investment and supply of the necessary materials for the creation of data centres. The state has announced its ability to provide an abundant and clean energy matrix, thus aiming to position the country as a global strategic centre for this specific segment (Câmara dos deputados, 2025a). However, this does not come without an environmental cost.

**Key points**

- Data centres have existed since the 1990s as facilities requiring constant power, cooling, and security (Balodis, 2012).
- Hyperscale data centres are large-scale, highly scalable infrastructures with major environmental and social impacts (Powell & Smalley, 2024).
- Their growth is driven by the increasing demand for artificial intelligence and big data processing.
- Location is now determined mainly by energy availability, not proximity to users (Rong et al., 2016).
- Brazil promotes itself as a global hub due to its “clean” energy matrix (Câmara dos Deputados, 2025a).

# Enviromental promises and impacts: A critical look at Brazil's data center expansion

Brazil is seeking to position itself strategically to become a new hub for data centres. This strategy is based mainly on the possibility of offering renewable energy and other natural advantages, such as geographical location and natural resources. This promise, however, overshadows significant environmental concerns and regulatory gaps regarding these facilities. Therefore, it is also necessary to conduct an analysis that considers both the country's potential and the practical risks of technological expansion.

The current discourse revolves around the fact that Brazil has an extensive renewable energy matrix, with more than 64% of its electricity generated from renewable sources, predominantly hydroelectric (Ministério de Minas Energia, 2023). This narrative presents an attractive opportunity for investors, reinforced by the government's REDATA regime, which offers federal tax exemptions through tax incentives for projects that meet specific sustainability criteria, such as the use of renewable energy (Agencia Gov, 2025).

Sustainability appears to be a predominant element of the digital economy agenda, having been announced by Finance Minister Fernando Haddad as a ‘digital and green’ economy (Agência Gov, 2025). In addition to an international investment strategy, REDATA also seeks to stimulate Brazil's digital ecosystem by establishing a commitment.

In addition to an international investment strategy, REDATA also seeks to stimulate Brazil's digital ecosystem, establishing a commitment that at least 10% of data centre capacity be allocated to the domestic market. According to government representatives, the initiative aims to include national companies in this data centre context, promoting a fertile environment for AI startups and entrepreneurs to develop applications locally, rather than relying on foreign infrastructure (Ministério do Desenvolvimento, Indústria e Comércio, 2025). The measure, which is justified by a discourse of national sovereignty, claims to include several Brazilian states by seeking geographical diversification of projects beyond São Paulo and Rio de Janeiro.

This government strategy has already attracted companies such as Microsoft and AWS, which have promised billions of dollars in AI-related investments. The country's installed data centre capacity is expected to grow from approximately 1 gigawatt to 8 gigawatts, potentially attracting up to $356 billion in investments over the next decade (REST OF WORLD 2025).

However, there are some inconsistencies. For example, those discourses do not address the space or pollution generated by data centre installations or do not consider that not every renewable energy solution is, in fact, sustainable. Furthermore, despite the rhetoric employed and the recommendations already made in this regard, there is a major regulatory concern involving the systematic exclusion of environmental authorities from policymaking. Investigations reveal that more than 80 interministerial meetings to discuss national data centre policy took place without the participation of the Ministry of the Environment. Proposals to eliminate environmental licensing requirements for data centres suggest a further worrying trend towards deregulation and weakened oversight (Martins, L. 2025a).

**Key Points**

- The government promotes renewable electricity matrix as a key investment attraction (Ministério de Minas e Energia, 2023).
- The REDATA regime offers federal tax incentives for projects using renewable energy (Agência Gov, 2025).
- The policy positions Brazil as pursuing a "digital and green" economy (Agência Gov, 2025).
- Dominant narratives emphasise growth and sovereignty while neglecting land use, pollution, and the limits of "renewable" energy.
- Environmental agencies have been excluded from policy meetings, indicating regulatory weakening and a shift towards deregulation (Martins, 2025a).

# Operational mechanics, spatial demands, and the scala AI City Project

As is characteristic of hyperscale data centres, they process enormous amounts of data, which requires complex interaction between IT infrastructure (POWELL; SMALLEY, 2024). This ecosystem also depends on extensive physical support infrastructure, such as uninterruptible power supplies, backup generators, and advanced cooling mechanisms, all of which require large physical spaces (Matko, 2019).

Globally, the scale of data infrastructure illustrates the magnitude of material and spatial requirements. There are currently around 12,000 data centres worldwide (Statista 2024a), of which 992 are classified as hyperscale facilities (Statista 2024b). Although definitions vary, IBM suggests that a hyperscale data centre typically contains at least 5,000 servers and occupies more than 10,000 square feet (approximately 929 $m^2$) (POWELL; SMALLEY, 2024). Some reach much larger dimensions, such as the Citadel Campus in Reno, Nevada, operated by the American company Switch, which occupies 7.2 million square feet (approximately 669,000 $m^2$), making it one of the largest data centre complexes in the world (Switch 2024). These figures illustrate the vast quantities of construction materials, metals and rare earth elements needed to sustain global digital expansion (Stacciarini, Gonçalves 2025).

A prime example of these dynamics in Latin America is the Scala AI City project in Eldorado do Sul, Brazil. Presented as the region’s first dedicated data centre industrial district, it is planned for a total land area of 7 million square metres, equivalent to roughly 1,000 football fields (Data Centre Dynamics 2024).

Another point of consideration regarding territory and area of construction is the physical aspect per se. Indeed, the location chosen to these installations also matter when evaluating the social and environmental impacts of data centres.

**Key Points**

- Hyperscale data centres process vast amounts of data, requiring complex IT systems and extensive physical infrastructure (Powell & Smalley, 2024).
- Support systems include uninterrupted power supplies, backup generators, and advanced cooling technologies (Matko, 2019).
- This infrastructure demands vast amounts of construction materials, metals, and rare earth elements, fuelling extractive pressures (Stacciarini & Gonçalves, 2025).
- In Latin America, the Scala AI City project in Eldorado do Sul, Brazil exemplifies this trend, spanning 7 million m$^2$ — about 1,000 football fields (Data Centre Dynamics, 2024).
- The location and territorial footprint of these facilities critically shape their social and environmental impacts.

# Data centers and so-called ‘sacrifice zones’

The truth is that the choice of where to install a data centre takes into account not only technical or infrastructural convenience, but also market values and the costs of expropriations to be made for the construction work. And this market-driven choice may end up leading to these infrastructures being installed in areas already marked by social vulnerability and environmental degradation. It is precisely the process of sacrificing environmental health and community well-being in the name of progress at any cost that ends up characterising the normalisation of so-called ‘green sacrifice zones’ (The Climate Reality Project, 2024).

This concept refers not only to the construction of technological infrastructure, but also to discourses about constructions that claim to be clean and sustainable. So-called green sacrifice zones (GSZs) are spaces and populations sacrificed for the supply, transport, installation, and operation of supposedly ‘green’ solutions, which include renewable energy, data storage, and other digital infrastructure, as well as areas used for the disposal of their material waste (Zografos and Robbins, 2020).

The truth is that even the installation of infrastructure using clean energy can reproduce extractive and colonial dynamics under the pretext of ecological transition, creating new forms of environmental injustice by externalising the social and ecological costs of digital and low-carbon transitions to marginalised territories and communities (Sovacool, 2021).

In other words, it is not enough for the Brazilian government to claim that data centres will be sustainable because they use clean energy if the other damages and impacts are not being properly and diligently assessed. The truth is that, without an impact assessment, digitisation and decarbonisation processes may end up reproducing the very inequalities they seek to resolve. In the case of data centres, this dynamic is becoming most visible in the Global South and in historically marginalised regions of the Global North.

These consequences can already be seen in examples from other parts of the world. In Europe, for example, sustainable technologies can generate localised pollution, spatial displacement and precarious working conditions (Brock, Sovacool and Hook, 2021). These are the same socio-ecological patterns now visible in digital infrastructure.

However, the problem is intensified when infrastructure is installed by foreign companies with considerable purchasing power in a country in the Global South, linking these developments to energy colonialism and illustrating how green transitions in the Global North often depend on the exploitation of peripheral regions and populations (Sánchez Contreras et al. 2024).

This is not to say that there are no problems related to sacrifice zones in the global north. In the United States, for example, the recent boom in AI-oriented facilities has intensified environmental and health inequalities. Data centres are increasingly located in low-income, predominantly Black communities, reinforcing historical patterns of environmental racism and infrastructural neglect (Marrinan, C., 2025). These facilities emit heat, noise, and air pollution, while consuming large amounts of electricity and water, compounding the burden on communities already living in polluted industrial corridors (MediaJustice, 2025; The Lens NOLA, 2025). The truth is that, anywhere in the world, those who suffer most are those who are already in a vulnerable situation.

The demands generated by these violent constructions and impositions of digital progress have been based on the need for robust regulation and community participation (The Lens NOLA, 2025), at the risk of these data centre corridors becoming the digital equivalents of the old sacrificed industrial zones, which local activists now call ‘Digital Cancer Alley’.

There is, therefore, a perception that the technological future being built in these regions is not neutral: it reflects political choices about whose land, water, and health can be compromised in the name of innovation.

The notion of sacrifice zones thus provides a critical framework for analysing where and how data centres are built. By concentrating environmental risk and infrastructural burden in already marginalised territories, they transform the spatial politics of the digital economy into a new frontier of environmental injustice. Far from being immaterial, the cloud is grounded in real space, and its foundations are often laid in places long considered expendable. Hence, the importance of analyses under the umbrella of the concept of sacrifice zones. Particular attention should be paid to those that claim to have ‘no environmental impact’ or to rely exclusively on ‘clean energy’. All technological expansion projects must be critically examined, not only in relation to their emissions or energy matrix, but also to their geography: where they are being built, who will benefit and who will bear their costs.

If such scrutiny is neglected, the pursuit of digital and green transitions risks deepening the very inequalities they seek to resolve, reinforcing patterns of vulnerability and exclusion under the banner of innovation. In other words, if there is real environmental concern, investment in initiatives to address it is needed, which is not necessarily being done in Brazil now.

**Key Points**

- Data centre locations are usually constructed in socially and ecologically vulnerable areas (The Climate Reality Project, 2024).
- Even projects powered by renewable energy can reproduce extractive and colonial dynamics, externalising environmental and social costs to marginalised regions (Sovacool, 2021).
- “Green sacrifice zones” (GSZs) consist of territories and communities harmed by the supposedly “clean” or “sustainable” infrastructure required for the digital and green economy (Zografos & Robbins, 2020).
- Without rigorous environmental impact assessments, digital and decarbonisation initiatives risk reinforcing the inequalities they claim to solve.
- The concept of sacrifice zones reveals how the digital economy’s spatial politics embed injustice, showing that the cloud is material, territorial, and unequal.
- Any claim of “no environmental impact” or “fully clean energy” must therefore be critically assessed in terms of where facilities are built, who benefits, and who bears the costs.

# The connection of Data Centers with rare earths and extractive practices in Brazil

As highlighted, the discourse presented and promoted by government initiatives clearly shows concern about energy use and commercialisation. However, the environmental footprint of data centre infrastructure goes far beyond electricity consumption, since the infrastructure itself requires the production of servers, chips and other high-performance components that depend on a highly extractive industrial chain, which in turn depends on minerals such as silicon, copper, lithium, cobalt and rare earth elements (Venditti 2023; Neves 2023; Zheng 2023). Although indispensable for the manufacture of semiconductors, batteries, and permanent magnets, the extraction and processing of these materials are often associated with unsustainable practices, including deforestation, water contamination, and significant carbon emissions (Zheng, 2023).

In Brazil, the search for these minerals is intertwined with a long history of territorial and resource conflicts. Currently, the country is positioning itself as an important global player in the production of 'minerals of the future,' such as lithium (Neves 2023) and copper (Venditti 2023), both essential for data centres and renewable energy infrastructure. However, this expansion is taking place in a context of widespread illegal mining and environmental violence. Gold mining, often linked to international supply chains for high-tech industries, has been documented as having devastating environmental and social impacts, particularly in the Amazon, where there is constant violation of indigenous lands, deforestation, and river contamination (Centro de Informação sobre Empresas e Direitos Humanos 2024 and JUNGMANN, 2024).

The scale of tensions related to mining in Brazil reflects the magnitude of the problem: in 2023 alone, 901 mining conflicts were recorded across the country, involving more than 2.8 million people and encompassing forced displacement, restricted access to water, and other socio-environmental damage (Agência Brasil 2025 b).

It is impossible to talk about data centres without considering the materials needed for their installation, taking into account not only their origin, but also how they are extracted and the consequences and trail of devastation they leave in their wake in Brazil itself.

**Key Points**

- Government and corporate narratives often focus on energy consumption, overlooking the broader environmental footprint of data centres, which extends to hardware production and global mineral extraction (Venditti, 2023; Neves, 2023; Zheng, 2023).
- The manufacture of servers, chips, and other components depends on highly extractive supply chains, reliant on silicon, copper, lithium, cobalt, and rare earth elements (Zheng, 2023).
- Extraction and processing of these materials are linked to deforestation, water contamination, toxic waste, and high carbon emissions, undermining claims of digital sustainability.
- Brazil positions itself as a key supplier of these so-called “minerals of the future,” notably lithium and copper (Neves, 2023; Venditti, 2023), which are crucial for both data infrastructure and renewable energy systems.
- However, this expansion occurs amid illegal mining, land conflicts, and environmental violence, particularly in the Amazon, where indigenous territories are invaded, forests cleared, and rivers polluted by gold extraction tied to global tech supply chains (Centre for Information on Business and Human Rights, 2024; Jungmann, 2024).
- In 2023 alone, Brazil recorded 901 mining conflicts, affecting over 2.8 million people and involving forced displacement, loss of water access, and other socio-environmental harms (Agência Brasil, 2025b).
- Discussing data centres without addressing the origin and social cost of their materials conceals the extractive and unequal dynamics underpinning digital progress.

# Energy consumption: Scale, metrics, and rising demand

In addition to the impacts related to land and territory, there is also the energy issue. Globally, more than 4% of total electricity consumption is attributed to information technology and communications infrastructure (Malmodin et al., 2024). However, this information will soon need to be updated, given that the combined energy use of data centres, artificial intelligence (AI) and cryptocurrency operations is expected to double by 2026 compared to 2022, when it reached 460 TWh (Vasconcelos, Y. 2025).

This data is especially relevant considering the projections for data centre installations. As described, hyperscale data centres consume a great deal of energy, which has grown in recent years. Before the pandemic, large data centres operated at 5 to 10 MW, while new developments since 2022 typically reach 20 to 50 MW (IP.REC 2025). In Brazil, total installed capacity to operate data centres is estimated at around 580 MW (not considering the amount for cooling, which represents 50% of the total amount), with projections exceeding 2 GW by 2028 (Vargas 2024). In addition to this, it is important to consider that according to studies, the use and technology developed for the operation of AI and machine learning will require increasingly larger amounts of electricity, which could even double from its level of 17 MW in 2022, reaching 35 GW in 2030 (NEWMARK, 2023).

In this regard, it is worth noting that energy use within a data centre is mainly divided between IT equipment and cooling systems, which together account for around 90% of total consumption (IP.REC 2025). AI workloads intensify this demand. Conventional cloud data centres typically require 20–30 MW, while those optimised for AI operate at 150–200 MW, with some hyperscale facilities reaching gigawatt capacities (Ryngelblum 2025).

In response, the sector has sought technical innovations to reduce relative consumption. The Scala AI City project in Rio Grande do Sul, for example, plans to implement liquid cooling systems designed for high-density AI training racks, which can require more than 150 kW each — significantly more than the typical 20 kW of conventional computing equipment (Data Centre Dynamics 2024). Although such technologies can improve energy efficiency (PUE), they do not offset the overall increase in absolute energy use, which remains a central challenge for the sustainable growth of infrastructure.

**Key Points**

- The ICT sector accounts for over 4% of global electricity consumption, a figure expected to rise sharply with the growth of AI and cryptocurrency operations (Malmodin et al., 2024; Vasconcelos, 2025).
- Combined energy use from data centres, AI, and crypto is projected to double by 2026 compared to 2022, when it reached 460 TWh (Vasconcelos, 2025).
- AI-optimised facilities consume far more power: conventional clouds use 20-30 MW, while AI-oriented ones reach 150-200 MW, with some hyperscale projects approaching gigawatt scales (Ryngelblum, 2025).
- Technical solutions, such as liquid cooling for high-density AI racks — as planned in the Scala AI City project (Rio Grande do Sul) — may enhance efficiency (Data Centre Dynamics, 2024), yet absolute energy consumption continues to rise, posing a major sustainability challenge.

# Environmental impacts: Carbon, water, and electronic waste

In addition to environmental issues related to their installation, the operation of data centres also has a large environmental footprint. related to its energy consumption, CO2 emissions and water usage.

The computing industry is estimated to account for between 1.7% and 2.8% of total global greenhouse gas emissions, reflecting its significant contribution to climate change (Freitag et al, 2021). As an energy-intensive sector, the carbon footprint of data centres depends directly on the energy sources they use, which means that in regions where electricity generation still relies on fossil fuels, $CO_2$ and other greenhouse gases are an unavoidable outcome (Aslan et al 2024 and Sanni et al. 2021). In Brazil, despite the predominance of renewable energy in its national matrix, the projected demand from data centres will place substantial strain on the power system. Forecasts suggest a requirement of 17,716 MW by 2038, which is equivalent to the consumption of a city with 43 million residents and, therefore, would entail the construction of new energy generation and transmission infrastructure, each carrying its own environmental implications (Veras Mota,C. 2025).

In addition to energy, water consumption for cooling is a critical concern, especially in drought-prone regions. Although some new projects promise less water consumption, widespread reliance on evaporative cooling remains problematic (Duan et al., 2012). The water footprint of artificial intelligence is particularly alarming. Research indicates that a single query to a large AI model such as ChatGPT can consume the equivalent of a 500 ml bottle of water, while training the GPT-3 model itself is estimated to have used up to 700,000 litres of drinking water (Pengfei et al., 2025).

This projection alone is alarming, especially when considering the number of hyperscale data centres that will operate to enable the operationalisation of artificial intelligence. According to projections, global water demand from AI servers is expected to reach between 4.2 and 6.6 billion cubic metres by 2027, which is equivalent to half of the UK's total water consumption (Pengfei et al., 2025).

There is an additional issue that must be considered. The water to be used must be clean (fresh). In that sense, even in cases where there is the pledge of less water use, it is important to consider that a single large data centre can otherwise consume millions of gallons of potable water daily, directly competing with local communities (The Washigton Post, 2023).

In response to these challenges, some facilities, such as the TikTok data centre in Ceará, say they will implement closed-loop cooling systems, projecting a minimum daily water consumption of only 30 m³. Even so, this consumption would be equivalent to the daily consumption of 230 residents of Fortaleza (Martins, L., Amorim, F., 2025; CNN Brasil, 2025).

There are also risks to vulnerable ecosystems, as already pointed out. The plan to build a huge data centre in Eldorado do Sul, a region devastated by catastrophic floods in 2024, risks putting additional pressure on already fragile ecosystems and recovering communities (Rest of World, 2025). This is because the project has a potential capacity of 4.75 gigawatts, which is far beyond the needs of the local population and is likely to require a great deal of energy to be produced and guaranteed uninterruptedly, which may be prioritised to the detriment of the city's population (Rest of World, 2025).

Finally, the entire life cycle of the IT equipment housed in these facilities contributes to a growing stream of electronic waste. The manufacture of servers and chips consumes large amounts of resources and rare earth elements, and the rapid obsolescence of this hardware generates a significant volume of electronic waste, often exported to developing countries with less stringent environmental controls. In this regard, it is important to note that REDATA makes no mention of how the electronic waste generated should be disposed of.

**Key Points**

- The computing industry contributes between 1.7% and 2.8% of global GHG emissions, underscoring its growing role in climate change (Freitag et al., 2021).
- The carbon footprint of data centres depends on the energy mix used; in regions reliant on fossil fuels, emissions are unavoidable (Aslan et al., 2024; Sanni et al., 2021).
- In Brazil, projected data centre demand could reach 17,716 MW by 2038, comparable to the consumption of a city of 43 million residents, requiring major new infrastructure (Veras Mota, 2025).
- Water consumption for cooling remains a major concern, especially in drought-prone areas. Despite promises of efficiency, most facilities still rely on evaporative cooling (Duan et al., 2012).
- Global water demand from AI servers could reach 4.2–6.6 billion m³ by 2027, roughly half of the UK's annual consumption (Pengfei et al., 2025).
- Even with "closed-loop" systems, water use remains high — for instance, the TikTok Ceará centre expects to consume 30 m³/day, equal to the daily use of 230 Fortaleza residents (Martins & Amorim, 2025; CNN Brasil, 2025a).

- The Eldorado do Sul project, planned in a flood-affected area, could add pressure to fragile ecosystems due to its 4.75 GW capacity and high energy demand (Rest of World, 2025).

- Electronic waste from server and chip obsolescence adds to the footprint. Manufacturing requires rare earth elements, while disposal often shifts to countries with weaker environmental oversight. The REDATA plan fails to address e-waste management.
- Although renewable energy reduces direct $CO_2$ emissions, it carries indirect environmental and social costs. Solar, wind, and hydropower developments can also cause territorial and ecological disruption (see section “Environmental Paradox of Renewable Energy”).
- Recognising these limits is essential to avoid greenwashing and support a fair and sustainable energy transition.

# The environmental paradox of renewable energy

Although the energy used for some data centre operations does not result in direct $CO_2$ emissions, this does not mean that it does not cause impacts, as we have already demonstrated. In addition to the impact on the surroundings of your facility, other aspects can also be considered based on the type of renewable energy chosen to subsidise each project.

This section does not aim to discourage the idea of the need for a transition to renewable energies, but seeks to reflect on the impacts that solar, wind, and hydroelectric energy can have and what their own environmental and social costs are. Recognising these limitations is crucial to preventing greenwashing narratives from hindering an energy transition that is truly fair and sustainable.

## Solar energy and its challenges

Specifically with regard to solar energy, it is clear that this can represent a real step forward in the energy transition. It works with photovoltaic (PV) systems that produce negligible emissions during operation, but its environmental footprint extends throughout its life cycle (Dones & Frischknecht, 1998; Frankl et al., 1998; Pacca et al., 2007). The manufacture of photovoltaic panels consumes a lot of energy and involves rare chemicals and materials, while end-of-life management presents recycling challenges (Fthenakis, 2000; Hamed & Alshare, 2022). The energy payback time ranges from 1.5 to 2.5 years, depending on the technology and site conditions (Raugei et al., 2007; Stoppato, 2008). Thus, the process involves hazardous materials and generates waste that is difficult to recycle at the end of the panel's life cycle.

Furthermore, it is true that large-scale solar power plants also require large tracts of land. In arid and semi-arid regions, these projects require substantial areas, often causing soil levelling, vegetation removal and habitat fragmentation (Tsoutsos et al., 2005; McDonald et al., 2009; Hernandez et al., 2014). In Brazil, photovoltaic plants have suppressed native vegetation, including endangered species, with pronounced effects on the Caatinga biome (Martins, R. 2025).

The destruction of native flora can disrupt local fauna and ecosystems (Saunders et al., 1991; Fahrig, 2003). In addition, their use also involves water consumption, as concentrated solar power (CSP) plants with wet cooling consume up to 3 $m^3$ of water per MWh, creating competition with agricultural and domestic water uses in areas with water scarcity (Hamed & Alshare, 2022; Turchi et al., 2010; Fthenakis & Kim, 2010; Carter & Campbell, 2009). These data allow us to assess that if investments in data centres justify their application with the use of solar energy, they will necessarily imply water consumption and the use of a large amount of land.

There are other impacts beyond the environmental ones. From a social perspective, it is worth noting that visual impacts, glare, and dust accumulation are additional operational challenges that affect both ecosystems and human communities (Mani & Pillai, 2010; He & Zhou, 2011; Hamed & Alshare, 2022). Although technological solutions, such as self-cleaning panels and agrivoltaic systems, can mitigate some impacts, the spatial footprint remains significant (Dupraz et al., 2011; Lamont & El Charr, 2011).

**Key Points**

- Low operational emissions: Photovoltaic (PV) systems produce negligible emissions during electricity generation (Dones & Frischknecht, 1998; Frankl et al., 1998; Pacca et al., 2007).
- Life cycle impacts: Manufacturing PV panels consumes substantial energy and rare materials, with end-of-life recycling posing significant challenges (Fthenakis, 2000; Hamed & Alshare, 2022).
- Energy payback: Panels typically require 1.5-2.5 years to generate the energy used in their production (Raugei et al., 2007; Stoppato, 2008).
- Land use: Large-scale solar plants require extensive land, often causing soil levelling, vegetation removal, and habitat fragmentation (Tsoutsos et al., 2005; McDonald et al., 2009; Hernandez et al., 2014).
- Biodiversity impacts: In Brazil, PV plants have displaced native flora, including endangered species, affecting ecosystems such as the Caatinga biome (Martins, R., 2025; Saunders et al., 1991; Fahrig, 2003).
- Water consumption: Concentrated solar power (CSP) with wet cooling uses up to 3 $m^3$ of water per MWh, potentially competing with agricultural and domestic needs (Hamed & Alshare, 2022; Turchi et al., 2010; Fthenakis & Kim, 2010; Carter & Campbell, 2009).
- Social and operational challenges: Visual impacts, glare, and dust accumulation affect both humans and ecosystems, though solutions like agrivoltaics and self-cleaning panels can mitigate some effects (Mani & Pillai, 2010; He & Zhou, 2011; Dupraz et al., 2011; Lamont & El Charr, 2011).

## Wind energy and its challenges

Wind energy, in turn, offers the advantage of generating electricity without combustion or direct emissions, but its environmental and social consequences are not insignificant (Leung

& Yang, 2012; Hamed & Alshare, 2022). The development of infrastructure, particularly in coastal dune fields such as Ceará, Brazil, has altered the geomorphology, compacted the sand, disrupted sediment transport, and impacted interdune lagoons and mangrove ecosystems (Meireles, 2011). Roads and transmission lines fragment habitats and interfere with wildlife migration (Saidur et al., 2011; Schreiber, 1977; Zink & Allen, 2011). Operationally, turbines pose risks to birds and bats through collisions (Lovich & Ennen, 2011; Drewitt & Langston, 2006; Sovacool, 2009).

There are also social challenges generated by the installation of wind farms. Noise, visual intrusion, and the shadow flicker effect affect neighbouring communities, while projects on ancestral lands can disrupt traditional livelihoods and cultural practices (Pedersen, 2011; Jaskelevicius & Uzpelkiene, 2009; Hamed & Alshare, 2022). In Ceará, these impacts can reduce access to marine resources for local fishermen, illustrating the intersection between ecological and socio-economic consequences (Felizola, L. 2025).

**Key Points**

- Low direct emissions: Wind energy generates electricity without combustion, reducing greenhouse gas output (Leung & Yang, 2012; Hamed & Alshare, 2022).
- Environmental impacts: Infrastructure development alters geomorphology, compacts sand, disrupts sediment transport, and affects interdune lagoons and mangroves in Ceará (Meireles, 2011).
- Habitat fragmentation: Roads and transmission lines interfere with wildlife migration (Saidur et al., 2011; Schreiber, 1977; Zink & Allen, 2011).
- Wildlife risks: Operational turbines can cause collisions with birds and bats (Lovich & Ennen, 2011; Drewitt & Langston, 2006; Sovacool, 2009).
- Social impacts: Noise, visual intrusion, and shadow flicker affect neighbouring communities (Pedersen, 2011; Jaskelevicius & Uzpelkiene, 2009; Hamed & Alshare, 2022).
- Cultural and livelihood disruption: Wind farms on ancestral lands can disturb traditional practices and reduce access to marine resources for local fishermen (Felizola, L., 2025).

### Hydropower and related issues

Hydropower, one of the pillars of Brazil's renewable energy matrix, also has its contradictions. Ecologically, hydroelectric projects cause extensive damage, including the flooding of vast areas of land, changes in the hydrology and water quality of rivers, sediment retention, and loss of terrestrial and aquatic biodiversity, with deforestation and habitat destruction leading to the disappearance of species essential for pollination and seed dispersal (Ferreira et al., 2013; Giongo, Mendes & Santos, 2015). These projects have also been associated with public health issues, ranging from the spread of infectious diseases in reservoirs to the mental health impacts resulting from the trauma of displacement and the disintegration of traditional ways of life (Giongo, Mendes & Santos, 2015, Queiroz & Motta-Veiga, 2012).

In addition to it, the large dams required for its operation have profound and systemic socio-environmental costs (Serra & Oliveira, 2019), leading to compulsory displacement (Custódio et al., 2024) and disproportionately affecting indigenous and riverine populations, leading to the separation of families and communities and the breakdown of social ties (Cavalcante et al., 2021; Pitombeira Carvalho & Sieben, 2019). The consequences go far beyond physical relocation, causing profound cultural and psychological damage. These communities often have a deep and symbolic connection to their territory, and forced displacement results in intangible losses, social suffering, sadness, and a profound sense of uprootedness (Ertzogue, Ferreira & Marques, 2017; Moret et al., 2021). In addition, their livelihoods, which are intrinsically linked to the environment, such as fishing, agriculture and extractivism, are severely compromised (Fainguelernt, 2020; Pase et al., 2016).

**Key Points:**

- Hydropower represents environmental impacts: Flooding of large areas, altered river hydrology and water quality, sediment retention, and loss of terrestrial and aquatic biodiversity (Ferreira et al., 2013; Giongo, Mendes & Santos, 2015).
- Deforestation and habitat loss: Leads to the disappearance of species critical for pollination and seed dispersal (Ferreira et al., 2013; Giongo, Mendes & Santos, 2015).
- Public health consequences: Spread of infectious diseases in reservoirs; mental health impacts from trauma of displacement and disruption of traditional lifestyles (Giongo, Mendes & Santos, 2015; Queiroz & Motta-Veiga, 2012).
- Socio-environmental costs of large dams: Compulsory displacement, disproportionate effects on indigenous and riverine populations, family separation, and breakdown of social ties (Serra & Oliveira, 2019; Custódio et al., 2024; Cavalcante et al., 2021; Pitombeira Carvalho & Sieben, 2019).
- Cultural and psychological damage: Forced relocation causes social suffering, sadness, uprootedness, and loss of symbolic connection to territory (Ertzogue, Ferreira & Marques, 2017; Moret et al., 2021).

- Impact on livelihoods: Fishing, agriculture, and extractivism are severely compromised due to environmental changes (Fainguelernt, 2020; Pase et al., 2016).

## Considerations on the main sources of renewable energy

One consideration that must be made is that the exclusive use of renewable energy in the construction of data centres may not be possible. For example, large-scale AI-oriented data centres, such as those planned in Brazil, require 150-300 MW of continuous power (Ryngelblum, 2025; Martins, L., Amorim, F., 2025). Even with the adoption of advanced cooling and efficiency measures, the absolute energy demand remains significant, illustrating the tension between the adoption of renewable energy and industrial energy needs (POWELL; SMALLEY, 2024). This dynamic opens the door to greenwashing, where companies highlight investments in renewable energy while downplaying their continued dependence on non-renewable energy. Studies indicate that a substantial portion of companies' environmental claims may be misleading (Câmara dos Deputados, 2025, b).

This is compounded by the fact that some sources have their own challenges. Solar and wind energy, for example, have an intrinsic obstacle in their intermittency. As sunlight and wind are variable, their energy production fluctuates, making them less predictable than conventional base load sources. This intermittency can limit their reliability, especially for energy-intensive operations such as data centres that depend on constant power availability. To ensure stability, renewable systems often rely on backup generation from fossil fuel power stations, which can offset some of the emissions reductions achieved (HASSAN et al., 2023).

To prevent the solutions provided from causing more harm than good, transparent regulation and independent verification are therefore essential to ensure that renewable initiatives reflect genuine environmental progress rather than a marketing strategy (Câmara dos Deputados, 2025 b).

In conclusion, although solar, wind and hydroelectric power are indispensable pillars of a low-carbon future, they are not themselves free from impacts, and their environmental costs must be weighed up. A sustainable energy transition must critically consider these environmental and social dimensions while ensuring that renewable energies deliver on their promise of genuine reductions in carbon emissions and ecological pressure (Hamed & Alshare, 2022; Dones & Frischknecht, 1998; Leung & Yang, 2012; Abbasi & Abbasi, 2000).

# The myth of job creation: A critical look at employment in the data center industry

A prominent argument in favour of encouraging data centre construction is its supposed potential for significant job creation. However, a careful analysis of other examples reveals that there is sometimes an increase in temporary jobs, but a shortage of permanent operational roles.

The job creation narrative is heavily dependent on the construction phase. Projects like Scala AI City in Rio Grande do Sul promise to generate more than 3,000 direct and indirect jobs in its first phase, while TikTok's data centre in Ceará is estimated to create more than 15,000 such positions (Damasceno, B., 2025). This aligns with the global trend that the construction of a large facility can employ 1,500 to 3,000 people at peak construction (The Wall Street Journal, 2025). However, these roles are inherently temporary.

The truth is that, once completed, the number of jobs plummets. A massive, one-million-square-foot data center, for example, might employ only about 100 full-time employees when operational (The Wall Street Journal, 2025). This represents a fraction of the workforce a similarly sized factory or office park would employ (The Wall Street Journal, 2025). The permanent staff required to manage IT equipment and facility operations typically consists of only a few people, making the long-term direct employment benefit to a host community surprisingly low (Tozzi, C. 2023).

This shortage of permanent jobs is compounded by the industry's relentless pursuit of automation. Data center leaders are actively investing in automated infrastructure with "remote monitoring and alerting" that allows fewer people to operate facilities remotely (Delfanti & Frey, 2020). In the Brazilian context, although policies such as the REDATA regime impose beneficial conditions, such as investment in local R&D, they do not require a high number of permanent hires. Furthermore, the highly specialised nature of operating advanced AI infrastructure can lead to dependence on foreign expertise, as the local labour market may not yet have a sufficiently broad pool of qualified professionals. This limits direct employment opportunities for the local community.

**Key Points**

- The job creation narrative is largely concentrated in the construction phase of data centres.
- Automation reduces labour needs: Remote monitoring and autonomous systems allow fewer staff to operate multiple sites (Delfanti & Frey, 2020).
- Local expertise limitations: Advanced AI infrastructure often requires foreign specialists, limiting local employment benefits.
- REDATA regime incentives exist (local R&D investment), but do not guarantee permanent employment.
- Overall, long-term socio-economic benefits for host communities are limited despite high construction-phase employment.

# Brazilian civil society and data centers

It is important to note that Brazilian civil society has mobilised to denounce the social and environmental impacts resulting from the installation of data centres, both through the production of materials denouncing this reality and through advocacy within government discussions on the issue.

The Consumer Defense Institute (IDEC) has played a central role in addressing the environmental implications of data centres in Brazil. In collaboration with the Terramar Institute, IDEC has organised public events and debates on *greenwashing* and the socio-environmental dimensions of digital infrastructure (IDEC, 2025a). It has also actively engaged in legislative advocacy, proposing amendments to the provisional measure that regulates data centres in the country—a process still under review by the National Congress (Congresso Nacional, 2025). However, such engagement has not always been straightforward: the organisation has faced restrictions, including denial of access to key documents (SAID, F., 2025) and exclusion from parliamentary debates on the development of public policy for data centres and its broader implications. Beyond advocacy, IDEC has produced influential materials, such as the report *"We Are Not the Backyard of Data Centres: A Study on the Socio-environmental and Climate Impacts of Data Centres in Latin America"* (IDEC, 2025b). Through this and other initiatives, the institute has strengthened regional cooperation networks with socio-environmental activists and organisations in countries including Chile, Mexico, and Uruguay.

In the Northeast, the Law and Technology Research Institute of Recife (IP.Rec) has emerged as another key voice. The institute has participated in open legislative hearings on the environmental consequences of data centres and has authored a series of technical reports—*"AI, Data Centres, and Environmental Impacts"*; *"Environmental Opacity in the Discussion on Transparency in the Artificial Intelligence Economy"* (IP.Rec, 2025b); and *"Contribution to Subsidy Taking for the National Data Centre Policy"* (IP.Rec and LAPIN, 2025). Together, these works identify critical aspects to be addressed in Brazil's forthcoming data centre regulatory framework while exposing the risks of installing such technologies without sufficient environmental safeguards.

The Public Policy and Internet Laboratory (LAPIN) has likewise contributed to the debate through its report *"Artificial Intelligence and Data Centres: Corporate Expansion in Tension with Socio-environmental Justice"* (LAPIN, 2025). The study highlights how unregulated corporate expansion of data infrastructure results in tangible social and environmental losses, emphasising the need to incorporate justice-based perspectives into national policy discussions

All the material presented here, although extremely relevant, has not been reported by the mainstream media, which indicates that, despite a civil society engaged with the issue of environmental impacts, these results have not been widely publicised and do not necessarily reach the most affected people.

## Brief overview

This initial analysis did not seek to cover all aspects related to data centres, but rather to contextualize their debates, their impacts, and why they matter in the Brazilian context.

The truth is that there are many cases around the world that bring with them examples of failures and challenges, but their reference needs to be careful. Brazil has a wide range of climates, and any comparison must consider not only usable energy sources but also ambient temperature and how this influences cooling possibilities, for example.

In any case, with the information considered, it becomes unequivocal that data centres, regardless of their energy source, impose profound and multifaceted impacts that extend far beyond their digital facade. Energy and water consumption creates direct competition with local populations, jeopardising scarcity in daily life and long-term resource security. Environmental degradation, from the destruction of native biomes for renewable energy projects to the alteration of fragile landscapes, poses irreversible risks, potentially displacing communities and eroding cultural identities, particularly among traditional populations.

Beyond energy and water, it is also necessary to consider the environmental footprint of manufacturing computers and high-performance chips for artificial intelligence, which depend on vast natural resources and rare earth elements. These materials are often extracted in environmentally destructive ways, particularly in countries in the Global South. The sector also produces substantial electronic waste, which tends to accumulate in socially and environmentally vulnerable regions, perpetuating an unsustainable cycle (Hull, 2010).

The lack of environmental authorities' involvement in discussions about these facilities in Brazil, coupled with the absence of robust safeguards and the enormous demand for natural resources, raises questions about whether the sustainability narrative is omitted from the planned incentives and raises doubts about the application of yet another form of digital extractivism cloaked in green rhetoric.

# References

ABBASI, S.A; ABBASI, Naseema. The likely adverse environmental impacts of renewable energy sources. **Applied Energy**, [S.L.], v. 65, n. 1-4, p. 121-144, abr. 2000. Elsevier BV. http://dx.doi.org/10.1016/s0306-2619(99)00077-x.

AGÊNCIA BRASIL. Conflitos de mineração no Brasil em 2023. Brasília: Agência Brasil, 2025, b.Disponível em <https://agenciabrasil.ebc.com.br/geral/noticia/2025-02/levantamento-aponta-901-ocorrencias-de-conflitos-de-mineracao-em-2023>.

AGÊNCIA GOV. Haddad detalha Política de Data Centers em conferência nos EUA. Agência gov. 2025. Disponível em <https://agenciagov.ebc.com.br/noticias/202505/haddad-apresenta-plano-de-crescimento-sustentavel-e-anuncia-politica-de-data-centers-em-conferencia-nos-eua>

ASLAN, Tuğana; HOLZAPFEL, Peter; STOBBE, Lutz; GRIMM, Andreas; NISSEN, Nils F.; FINKBEINER, Matthias. Toward climate neutral data centers: greenhouse gas inventory, scenarios, and strategies. **Iscience**, [S.L.], v. 28, n. 1, p. 111637, jan. 2025. Elsevier BV. http://dx.doi.org/10.1016/j.isci.2024.111637.

Balodis, R., Opmane, I. (2012). History of Data Centre Development. In: Tatnall, A. (eds) Reflections on the History of Computing. IFIP Advances in Information and Communication Technology, vol 387. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-33899-1_13

BROCK, Andrea; SOVACOOL, Benjamin K.; HOOK, Andrew. Volatile Photovoltaics: green industrialization, sacrifice zones, and the political ecology of solar energy in germany. **Annals Of The American Association Of Geographers**, [S.L.], p. 1-23, 22 fev. 2021. Informa UK Limited. http://dx.doi.org/10.1080/24694452.2020.1856638

CÂMARA DOS DEPUTADOS. Matriz de energia limpa e renovável torna o Brasil atraente para instalação de data centers Fonte: Agência Câmara de Notícias. 2025a. Dipsonivel em https://www.camara.leg.br/noticias/1196158-matriz-de-energia-limpa-e-renovavel-torna-o-brasil-atraente-para-instalacao-de-data-centers/

Câmara dos Deputados. Especialistas defendem regulamentação da publicidade sobre sustentabilidade ambiental Fonte: Agência Câmara de Notícias . Brasilia. Câmara dos Deputados. 2025 b Disponível em https://www.camara.leg.br/noticias/1185845-especialistas-defendem-regulamentacao-da-publicidade-sobre-sustentabilidade-ambiental/

Carter, NT, Campbell, RJ. 2009. Water issues of concentrating solar power (CSP) electricity in the U.S. Southwest. Congressional Research Service, Washington DC.

Cavalcante, M.M.A., Costa, G.M., Silva, G.V.L., & Moret, A.S. (2021). Hidrelétricas e Unidade de Conservação na Amazônia. Mercator, 20, 1-12. https://www.scielo.br/j/mercator/a/gQS78YPmMpkWrtMJntbG3qz/?lang=pt .

Centro de Informação sobre Empresas e Direitos Humanos. Brasil: Multinacionais podem estar usando ouro ligado ao garimpo ilegal e a violações de direitos indígenas em suas cadeias de produção; incl. comentários das empresas. 2024. Disponível em: https://www.business-humanrights.org/pt/%C3%BAltimas-not%C3%ADcias/brasil-multinacionais-podem-estar-usando-ouro-ligado-ao-garimpo-ilegal-e-a-viola%C3%A7%C3%B5es-de-direitos-ind%C3%ADgenas-em-suas-cadeias-de-produ%C3%A7%C3%A3o-incl-coment%C3%A1rios-das-empresas/

CNN BRASIL. **ONS aprova projeto de data centers estimado em R$ 50 bilhões, diz empresa.** CNN Brasil 2025a Available at: https://www.cnnbrasil.com.br/economia/investimentos/ons-aprova-projeto-de-data-centers-estimado-em-r-50-bilhoes-diz-empresa/ [Accessed 7 October 2025].

CONTRERAS, Josefa Sánchez; RUIZ, Alberto Matarán; CAMPOS-CELADOR, Alvaro; FJELLHEIM, Eva Maria. Energy Colonialism: a category to analyse the corporate energy transition in the global south and north. **Land**, [S.L.], v. 12, n. 6, p. 1241, 16 jun. 2023. MDPI AG. http://dx.doi.org/10.3390/land12061241.

Custódio, D., Lorusso, J., & Cavalcante, L., A. N. Lopes (2022). Usinas Hidrelétricas E Seus Impactos Ambientais. Anais da Exposição Anual de Tecnologia, Educação, Cultura, Ciências e Arte do Instituto Federal de São Paulo-Campus Guarulhos -v.2. https://revista.gru.ifsp.edu.br/exatecca/article/download/76/31

DATA CENTRE DYNAMICS. 2024. **Cidade de data centers é anunciada no RS para responder a demanda de IA.** Available at: https://www.datacenterdynamics.com/br/not%C3%ADcias/cidade-de-data-centers-e-anunciada-no-rs-para-responder-a-demanda-de-ia/#:~:text=Canais-,%E2%80%9CCidade%20de%20Data%20Centers%E2%80%9D%20%C3%A9%20anunciada%20no%20RS%20para,responder%20%C3%A0%20demanda%20de%20IA&text=O%20governo%20do%20Estado%20do,500%20milh%C3%B5es)%20na%20fase%201. [Accessed 7 October 2025].

DAMASCENO, B. Data Center da Casa dos Ventos em Caucaia deve gerar 15 mil empregos na 1ª fase; veja projeto .Diario do Nordeste. Disponível em https://diariodonordeste.verdesmares.com.br/negocios/data-center-da-casa-dos-ventos-em-caucaia-deve-gerar-15-mil-empregos-na-1-fase-veja-projeto-1.3664363

DELFANTI, Alessandro; FREY, Bronwyn. Humanly Extended Automation or the Future of Work Seen through Amazon Patents. **Science, Technology, & Human Values**, [S.L.], v. 46, n. 3, p. 655-682, 29 jul. 2020. SAGE Publications. http://dx.doi.org/10.1177/0162243920943665.

DONES, R.; FRISCHKNECHT, R. Life-cycle assessment of photovoltaic systems. Energy Policy, v. 26, n. 1, p. 57-70, 1998.

Drewitt A, Langston R. Assessing the impacts of the wind farms on birds. International Journal of Avian Science 2006;148:29-42

DUAN, Zhiyin; ZHAN, Changhong; ZHANG, Xingxing; MUSTAFA, Mahmud; ZHAO, Xudong; ALIMOHAMMADISAGVAND, Behrang; HASAN, Ala. Indirect evaporative cooling: past, present and future potentials. **Renewable And Sustainable Energy Reviews**, [S.L.], v. 16, n. 9, p. 6823-6850, dez. 2012. Elsevier BV. http://dx.doi.org/10.1016/j.rser.2012.07.007

Dupraz C, Marrou H, Talbot G, Dufour L, Nogier A, Ferard, Y. 2011. Combining solar photovoltaic panels and food crops for optimising land use: towards new agrivoltaic schemes. Renew. Energ. 2011:36:2725-32

Ertzogue, M. H., Ferreira, D. T. A. M., & Marques, E. E. (2017). “É a morte do Rio Tocantins, eu sinto isso”: Desterritorialização e perdas simbólicas em comunidades tradicionais atingidas pela hidrelétrica de Estreito, TO. Sociedade e Natureza, 29(1), 53-62. https://doi.org/10.1590/1982-451320170104

EWIM, Daniel Raphael Ejike; NINDUWEZUOR-EHIOBU, Nwakamma; ORIKPETE, Ochuko Felix; EGBOKHAEBHO, Blessed Afeyokalo; FAWOLE, Akeeb Adepoju; ONUNKA, Chiemela. Impact of Data Centers on Climate Change: a review of energy efficient strategies. The Journal Of Engineering And Exact Sciences, [S.L.], v. 9, n. 6, p. 1-15, 17 ago. 2023. Universidade Federal de Vicosa. http://dx.doi.org/10.18540/jcecvl9iss6pp16397-01e.

FAINGUELERNT, Maíra Borges. Impactos da Usina Hidrelétrica de Belo Monte: uma análise da visão das populações ribeirinhas das reservas extrativistas da terra do meio. **Civitas - Revista de Ciências Sociais**, [S.L.], v. 20, n. 1, p. 43, 26 maio 2020. EDIPUCRS. http://dx.doi.org/10.15448/1984-7289.2020.1.35906

Frankl P, Masini A, Gamberale M, Toccaceli D. Simplified life-cycle analysis of PV systems in buildings: present situation and future trends. Progress in Photovoltaics Research and Applications 1998;6:137-46.

FREITAG, Charlotte; BERNERS-LEE, Mike; WIDDICKS, Kelly; KNOWLES, Bran; BLAIR, Gordon S.; FRIDAY, Adrian. The real climate and transformative impact of ICT: a critique of estimates, trends, and regulations. **Patterns**, [S.L.], v. 2, n. 9, p. 100340, set. 2021. Elsevier BV. http://dx.doi.org/10.1016/j.patter.2021.100340.

FELIZOLA, L. Mirando energia limpa, eólicas offshore podem sacrificar pesca artesanal no Ceará. MONGABAY. 2025. Disponível em https://brasil.mongabay.com/2025/04/mirando-energia-limpa-eolicas-offshore-podem-sacrificar-pesca-artesanal-no-ceara/

Ferreira, L. V., Cunha, D. A., Chaves, P.P, Matos, D.C.L., & Parolin, P. (2013). Impacts of hydroelectric dams on alluvial riparian plant communities in Eastern Brazilian Amazonian. Anais da Academia Brasileira de Ciências, 85 (3), 1013-1023. https://doi.org/10.1590/S0001-37652013000300012

Fthenakis V, Kim HC. Life-cycle uses of water in U.S. electricity generation. Renewable and Sustainable Energy Reviews 2010;14(7):2039-48.

Fthenakis. End-of-life management and recycling of PV modules. Energy Policy 2000;28:1051-8

Giongo, C. R., Mendes, J. M. R., & Santos, F. K. (2015). Desenvolvimento, saúde e meio ambiente: contradições na construção de hidrelétricas. Serviço Social & Sociedade, 123, 501-522. https://doi.org/10.1590/0101-6628.034.

GUIDI, G. et al. Environmental Burden of United States Data Centers in the Artificial Intelligence Era. arXiv:2411.09786. 2024. Disponível em: https://arxiv.org/abs/2411.09786. Acesso em: 07 out. 2025.

HAMED, A.; ALSHARE, Z. Environmental impacts of renewable energy: Solar and wind. Journal of Sustainable Development of Energy Water and Environ, 2022.DOI:10.13044/j.sdewes.d9.0387

HASSAN, Qusay; ALGBURI, Sameer; SAMEEN, Aws Zuhair; SALMAN, Hayder M.; JASZCZUR, Marek. A review of hybrid renewable energy systems: solar and wind-powered solutions. **Results In Engineering**, [S.L.], v. 20, p. 101621, dez. 2023. Elsevier BV. http://dx.doi.org/10.1016/j.rineng.2023.101621.

He G, Zhou C, Li Z. Review of self-cleaning method for solar cell array. Procedia Engineering 2011;16(2011):640-5

Hernandez RR, Easter SB, Murphy-Mariscal ML, Maestre FT, Tavassoli M, Allen EB, Barrows CW, Belnap J, Ochoa-Hueso R, Ravi S, Allen MF. Environmental impacts of utility-scale solar energy. Renewable and Sustainable Energy Reviews 2014; 29:766

HULL, E. Poisoning the Poor for Profit: The Injustice of Exporting Electronic Waste to Developing Countries, 21 *Duke Environmental Law & Policy Forum* 1-48 (Fall 2010) Available at: https://scholarship.law.duke.edu/delpf/vol21/iss1/1

Idec. Não somos quintal de data centers: um estudo sobre os impactos socioambientais e climáticos dos data centers na América Latina. IDEC> 2025a Disponível em https://idec.org.br/pdf/idec_estudo-nao-somos-quintal-de-data-centers.pdf

IDEC. Idec realiza evento sobre greenwashing e data centers.  IDEC, 2025 b disponível em https://idec.org.br/noticia/idec-realiza-evento-sobre-greenwashing-e-data-centers

INSTITUTO DE PESQUISA EM DIREITO & TECNOLOGIA DE RECIFE IP.REC. *IA, Data Centers e os impactos ambientais*. [S.l.]: IP.rec, 2025. Disponível em: https://ip.rec.br/publicacoes/ia-data-centers-e-os-impactos-ambientais/. Acesso em: 6 out. 2025.

IP.REC. Opacidade ambiental na discussão sobre transparência da economia da Inteligência Artificial; IP.Rec. 2025b disponível em < https://ip.rec.br/wp-content/uploads/2025/06/V2-Opacidade-Ambiental-e-Desastre-Ecologico-na-IA.pdf >

IP.REC & LAPIN. Contribuição à tomada de subsídios da Política Nacional de Data Centers; IPRE& LAPIN 2025. Disponível em **https://ip.rec.br/publicacoes/contribuicao-a-tomada-de-subsidios-da-politica-nacional-de-data-centers/**

Jaskelevicius B, Uzpelkiene BN. J Visual impact evaluation in wind farms. Journal of Environmental Engineering and Landscape Management 2009;34:145-53.

JUNGMANN, Luiza Greenhalgh. Ecocídio e genocídio privados na Terra Indígena Yanomami. Consultor Jurídico. Disponível em: https://www.conjur.com.br/2024-nov-03/ecocidio-e-genocidio-privados-na-terra-indigena-yanomami/. Acesso em: 25/03/2025.

LAPIN. “Inteligência Artificial e Data Centers: A Expansão Corporativa em Tensão com a Justiça Socioambiental”. LAPIN 2025. Disponível em https://lapin.org.br/2025/08/11/confira-o-relatorio-inteligencia-artificial-e-data-centers-a-expansao-corporativa-em-tensao-com-a-justica-socioambiental/

Lamont L, El Charr L. Enhancement of a stand-alone photovoltaic system’s performance: reduction of soft and hard shading. Renewable Energy 2011;36 (4):1306- 10.

Leung, Y. Yang, Wind energy development and its environmental impact: a review, Renew. Sustain. Energy Rev 2012;16 (1):1031-9.

Lovich JE, Ennen JR. Wildlife conservation and solar energy development in the desert southwest, United States. BioScience 2011;61(2):982-92.

Malmodin, J;  Lövehagen, N., Bergmark, P. Lundén, D. ICT sector electricity consumption and greenhouse gas emissions - 2020 outcome, Telecommunications Policy, Volume 48, Issue 3, 2024, 102701, ISSN 0308-5961, https://doi.org/10.1016/j.telpol.2023.102701.

Mani M, Pillai R. Impact of dust on solar photovoltaic (PV) performance: research status, challenges and recommendations. Renewable and Sustainable Energy Reviews 2010;14(9):3124-31

Marrinan, C. Tech Policy Press, 2025. https://www.techpolicy.press/data-center-boom-risks-health-of-already-vulnerable-communities/

Martins, L. A boiada da IA Governo escanteia Ministério do Meio Ambiente e ignora riscos em política nacional de data centers.The Intercept Brasil. 2025a. Disponivel em https://www.intercept.com.br/2025/04/28/governo-escanteia-ministerio-do-meio-ambiente-e-ignora-riscos-em-politica-nacional-de-data-centers/

Martins, L., Amorim, F. TRAN$AÇÃO ENERGÉTICA EXCLUSIVO: Data center do TikTok gastará energia equivalente ao consumo de 2,2 milhões de brasileiros, revela estudo interno. The Intercept Brasil. 2025. Disponivel em https://www.intercept.com.br/2025/07/03/data-center-tiktok-energia-estudo-interno/

Martins, Rafael. Caatinga desmatada para instalação de painéis solares mobiliza comunidade na Bahia. MogoBay. 2025 DIsponível em https://brasil.mongabay.com/2025/02/caatinga-desmatada-para-instalacao-de-paineis-solares-mobiliza-comunidade-na-bahia/

MATKO, Vojko; BREZOVEC, Barbara; MILANOVIč, Miro. Intelligent Monitoring of Data Center Physical Infrastructure. **Applied Sciences**, [S.L.], v. 9, n. 23, p. 4998, 20 nov. 2019. MDPI AG. http://dx.doi.org/10.3390/app9234998.

McDonald R, Fargione J, Kiesecker J, Miller WM, Powell J. Energy sprawl or energy efficiency: climate policy impacts on natural habitat for the United States of America. PLoS One 2009;4.8: 1-11.

MEDIA JUSTICE. The People Say No: Resisting Data Centers in the South. 2025. Disponível em: https://mediajustice.org/wp-content/uploads/2025/09/MediaJustice-Data-Centers-Report.pdf. Acesso em: 07 out. 2025.

MEIRELES, Antonio Jeovah de Andrade. Danos socioambientais originados pelas usinas eólicas nos campos de dunas do Nordeste brasileiro e critérios para definição de alternativas locacionais. **Confins**, Brasil, v. 11, 2011. OpenEdition. http://dx.doi.org/10.4000/confins.6970.

Ministério do Desenvolvimento, Indústria, Comércio e Serviços. MP cria o Redata, que estimula data centers e impulsiona economia digital no Brasil. Gov. BR. 2025 Disponível em https://www.gov.br/mdic/pt-br/assuntos/noticias/2025/setembro/mp-cria-o-redata-que-estimula-datacenters-e-impulsiona-economia-digital-no-brasil

Ministério de Minas e Energia. Energia de hidrelétricas é considerada uma das mais seguras e limpas. GOV. 2023. Disponível em https://www.gov.br/mme/pt-br/assuntos/noticias/energia-de-hidreletricas-e-considerada-uma-das-mais-seguras-e-limpas

Moret, A.S., Santos, C.M., Andrade, R.A.O., Simão, B.P., & Barba, C.H. (2021). Expandindo a concepção de atingidos por UHE: Assentamentos Vila Jirau e Vila da Penha -Rondônia. (2021). Ambiente & Sociedade, 24, 1-17. https://doi.org/10.1590/1809-4422asoc20200132r2vu2021L3DAO.

Neves. E. Brasil se lança na corrida pela produção do lítio, o mineral do futuro Leia mais em: https://veja.abril.com.br/agenda-verde/brasil-se-lanca-na-corrida-pela-producao-do-litio-o-mineral-do-futuro/. Veja. 2023, Disponível em https://veja.abril.com.br/agenda-verde/brasil-se-lanca-na-corrida-pela-producao-do-litio-o-mineral-do-futuro/

NEWMARK. 2023 U.S. Data Center Market Overview & Market Clusters January 2024. Disponível em https://www.nmrk.com/insights/market-report/2023-u-s-data-center-market-overview-market-clusters

PACA, S.; BATTISTI, A.; HALL, D. Energy payback times of photovoltaic modules. Energy, v. 32, n. 3, p. 367-374, 2007.

Pacca S, Sivaraman D, Keoleian GA. Parameters affecting the life cycle performance of PV technologies and systems. Energy Policy 2007;35:3316-26

Pase, H. L., Rocha, H. J. D., Santos, E. R. D., & Patella, A. P. D. (2016). The sociopolitical conflict in hydroelectric enterprises. Ambiente & Sociedade, 19(2), 45-66. https://doi.org/10.1590/1809-4422ASOC135480V1922016.

Pedersen E. Health aspects associated with wind turbine noise. Results from three field studies. Noise Control Engineering Journal 2011;59(1):47-53.

PENGFEI, L. Yang, J., Islam, M.A., Ren, S. Making AI Less "Thirsty": Uncovering and Addressing the Secret Water Footprint of AI Models. Communications of the ACM. 2025. https://doi.org/10.48550/arXiv.2304.03271

Pitombeira Carvalho, G. D. A., & Sieben, A. (2019). Da ilha de São José ao reassentamento coletivo Baixão em Babaçulândia (TO): efeitos da Usina Hidrelétrica de Estreito na Amazônia. Cuadernos de Geografía: Revista Colombiana de Geografía, 28(1), 175-191. https://doi.org/10.15446/rcdg.v28n1.73572

POWELL, P.; SMALLEY, I. What is a hyperscale data center? 2024. IBM. Disponível em: https://www.ibm.com/br-pt/topics/hyperscale-data-center. Acesso em: 18 oct. 2025.

Queiroz, A. R., & Motta-Veiga, M. (2012). Análise dos impactos sociais e à saúde de grandes empreendimentos hidrelétricos: lições para uma gestão energética sustentável [Analysis of the social and health impacts of large hydroelectric plants: lessons for asustainable energy management]. Ciência & Saúde Coletiva, 17(6), 1387-1398. https://doi.org/10.1590/s1413-81232012000600002.

Raugei M, Bargigli S, Ulgiati S. Life cycle assessment and energy pay-back time of advanced photovoltaic modules: CdTe and CIS compared to poly-Si. Energy 2007;32:1310-8.

REST OF WORLD. Brazil wants to be a sustainable data center hub. Environmentalists are skeptical. 2025. Disponível em: https://restofworld.org/2025/brazil-data-center-environmental-risk/ Acesso em: 6 out. 2025.

RONG, Huigui; ZHANG, Haomin; XIAO, Sheng; LI, Canbing; HU, Chunhua. Optimizing energy consumption for data centers. **Renewable And Sustainable Energy Reviews**, [S.L.], v. 58, p. 674-691, maio 2016. Elsevier BV. http://dx.doi.org/10.1016/j.rser.2015.12.283.

RYNGELBLUM, Ivan. Brasil avança em data centers e caminha para se tornar a nova fronteira do setor. Neofeed. 2025. Disponível em: https://neofeed.com.br/negocios/brasil-avanca-em-data-centers-e-caminha-para-se-tornar-a-nova-fronteira-do-setor/. Acesso em: 25/08/2025.

SAID, F. Governo nega acesso a minuta da política nacional de data centers. Metropoles. 2025. Disponível em https://www.metropoles.com/brasil/governo-nega-acesso-a-minuta-da-politica-nacional-de-data-centers

Saidur R, Rahim NA, Islam MR, Solangi KH. Environmental impact of wind energy, Renew. Sustain. Energy Rev 2011;15 (5):2423–30.

SANNI, Shereefdeen Oladapo; ORICHA, Joseph Yakubu; OYEWOLE, Taoheed Oluwafemi; BAWONDA, Femi Ikotoni. Analysis of backup power supply for unreliable grid using hybrid solar PV/diesel/biogas system. **Energy**, [S.L.], v. 227, p. 120506, jul. 2021. Elsevier BV. http://dx.doi.org/10.1016/j.energy.2021.120506.

Saunders DA, Hobbs RJ, Margules CR. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 1991;5(1):18-32

Schreiber RK, Graves JH. Powerline corridors as possible barriers to the movement of small mammals. American Midland Naturalist 1977;97(2):504-8

Serra, J. P., & de Oliveira, T. A. (2020). Impactos ambientais decorrentes da construção de barragens de usinas hidrelétricas: reflexões e desdobramentos físico-naturais. Carmino hayashi diego de souza sardinha, 64. https://www.researchgate.net/publication/344503533.

SOVACOOL, B. K. Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation. Energy Research & Social Science, v. 73, 2021.

Sovacool BK. Contextualizing avian mortality: a preliminary appraisal of bird and bat fatalities from wind, fossil-fuel, and nuclear electricity. Energy Policy 2009.

STACCIARINI, A.; GONÇALVES, L. Data Centers, Minerais Críticos, Energia e Geopolítica: as bases da Inteligência Artificial. Energy & Environment, 2025. DOI: 10.14393/SN-v37-2025-77215

STATISTA. Number of data centres worldwide. 2024a. Disponível em: https://www.statista.com. Acesso em: 6 out. 2025.

STATISTA. Hyperscale data centre statistics. 2024b. Disponível em: https://www.statista.com. Acesso em: 6 out. 2025.

Stoppato A. Life cycle assessment of photovoltaic electricity generation. Energy 2008

SWITCH. Switch TAHOE RENO Now Open: Largest, Most Advanced Data Center Campus in the World. Switch, 2024. https://www.switch.com/switch-tahoe-reno-data-center-now-open/

THE CLIMATE REALITY PROJECT. Sacrifice Zones 101. Disponível em: https://www.climaterealityproject.org/sacrifice-zones. Acesso em: 07 out. 2025.

THE LENS NOLA. Data centers spark fears of a digital ‘cancer alley’ in Louisiana. 2025. Disponível em: https://thelensnola.org/2025/09/25/data-centers-spark-fears-of-a-digital-cancer-alley-in-louisiana/. Acesso em: 07 out. 2025.

The Washington Post. A new front in the water wars: Your internet use. 2023 .Disponível em https://www.washingtonpost.com/climate-environment/2023/04/25/data-centers-drought-water-use/

THE WALL STREET JOURNAL. 2025. **The AI Data-Center Boom Is a Job-Creation Bust** Available at: https://www.wsj.com/tech/ai-data-center-job-creation-48038b67

TOZZI, C. . 2023. **How Many Jobs Do Data Centers Create? It Depends.** DATA CENTER KNOWLEDGEAvailable at: https://www.datacenterknowledge.com/operations-and-management/how-many-jobs-do-data-centers-create-it-depends [Accessed 7 October 2025].

Tsoutsos T, Frantzeskaki N, Gekas V. Environmental impacts from the solar energy technologies. Energy Policy 2005;33(3):289-96.

Turchi, C.S., Wagner, M.J., Kutscher, C.F., 2010. Water Use in Parabolic Trough Power Plants: Summary Results from WorleyParsons’ analyses, NREL/TP5500-49468.

VARGAS, I. Brasil já Colhe benefícios do boom dos data centers. Valor Econômico 2024. Disponível em https://valor.globo.com/publicacoes/especiais/investimento-estrangeiro/noticia/2024/11/06/brasil-ja-colhe-beneficios-do-boom-dos-data-centers.ghtml

Vasconcelos, Y.. Os impactos ambientais da computação. Resvista Fapesp 2025. Disponível em: https://revistapesquisa.fapesp.br/os-impactos-ambientais-da-computacao/ Acesso em: 6 out. 2025.

VENDITTI, B. Why Copper Is Critical for Data Centers. 2023. DIsponível em <https://elements.visualcapitalist.com/why-copper-is-critical-for-data-centers/>

VERAS MOTA, C. Quanta água o ChatGPT 'bebe' para responder sua pergunta? Data centers se multiplicam no Brasil e cientistas tentam estimar impacto. BBC. 2025.Disponível em: https://www.bbc.com/portuguese/articles/cy4dvlyg5j3oAcesso em: 6 out. 2025.

ZHENG, M. The Environmental Impacts of Lithium and Cobalt Mining. Earth.Org. 2023. Disponível em https://earth.org/lithium-and-cobalt-mining/

Zink TA, Allen MF, Heindl-Tenhunen B, Allen EB. The effect of a disturbance corridor on an ecological reserve. Restoration Ecology 1995;3(4):304-10.

ZOGRAFOS, C.; ROBBINS, P. Green sacrifice zones, or why a green new deal cannot ignore the cost shifts of just transitions. One Earth, v. 3, n. 5, p. 543-546, 2020.