Commodifying Climate: Understanding Data Centres in Brazil

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Abstract

Data centres have come under increasing scrutiny due to their demand for natural resources. As a symptom of contemporary societies' dependence on digital technologies, investments in this infrastructure raise questions about what kind of economic development we are building and which ecological relations take shape in this process. Seeking to understand what kind of value is produced in data centers and how the infrastructure-environment relationship operates within this production, this research proposes understanding data centers as sites of modulation and control of climatic variables oriented toward computation. Above all, in dialogue with data center studies, the political economy of the environment, the anthropology of infrastructure, and entropy studies, this thesis argues that data centers, through the distributed agency between humans and their artifacts, result in a technological ecosystem. Such an ecosystem is a site of experimentation for the production of a type of climate contractually enforced for the operation of servers and other computational devices. It is therefore a mode of capitalist exploitation based on negentropic practices of energetic, thermal, and informational control, such that the resulting commodity is a temporality supposedly "cleansed" of the possibility of catastrophic events.

To arrive at these conclusions, the research was based on fieldwork conducted primarily with data center companies and workers located in the metropolitan region of São Paulo. The aim was to understand their worldviews, sociotechnical relations, and the environmental issues that shape the functioning of this infrastructure. Additionally, I participated in trade fairs and events aimed at companies in the sector, which provided me with contact with the discourses and modes of sociability of this milieu. This contact made it possible to identify latent contradictions, as, for

example, the tension between the promise of ecologically sustainable development and the need for exponential growth.

Résumé

Les centres de données font l'objet d'un examen croissant en raison de leur demande en ressources naturelles. Symptôme de la dépendance des sociétés contemporaines aux technologies numériques, les investissements dans cette infrastructure soulèvent des questions sur le type de développement économique que nous construisons et sur les relations écologiques qui prennent forme dans ce processus. Cherchant à comprendre quel type de valeur est produit dans les centres de données et comment la relation entre infrastructure et environnement s'y déploie, cette recherche propose de comprendre les centres de données comme des lieux de modulation et de contrôle de variables climatiques orientées vers le calcul. Surtout, en dialogue avec les data center studies, l'économie politique de l'environnement, l'anthropologie des infrastructures et les études sur l'entropie, cette thèse soutient que les centres de données, à partir de l'agence distribuée entre les humains et leurs artefacts, constituent un écosystème technologique. Un tel écosystème est un lieu d'expérimentation pour la production d'un type de climat contractuellement imposé au fonctionnement des serveurs et d'autres dispositifs computationnels. Il s'agit donc d'un mode d'exploitation capitaliste fondé sur des pratiques négentropiques de contrôle énergétique, thermique et informationnel, de sorte que la marchandise qui en résulte est une temporalité supposément «nettoyée» de la possibilité d'événements catastrophiques.

Pour parvenir à ces conclusions, la recherche s'est appuyée sur un travail de terrain mené principalement auprès d'entreprises et de travailleurs de centres de données situés dans la région métropolitaine de la ville de São Paulo. En outre, j'ai participé à des salons professionnels et à des événements destinés aux entreprises du secteur, ce qui m'a permis d'entrer en contact avec les discours et les modes de sociabilité propres à ce milieu. Ce contact a permis d'identifier des

contradictions latentes, comme par exemple la tension entre la promesse d'un développement écologiquement durable et la nécessité d'une croissance vertigineuse.

Introduction

In recent years, the world has witnessed a proliferation of data centres. According to S&P Global, this growth translated into deals totaling USD 61 billion in 2025, a record. Driven by the recent AI frenzy, there are no forecasts of a slowdown in the near future. This growth is also reflected in Brazil. In a survey conducted by Brandão and Lins (2025), 554 data centres were identified in the country (465 privately owned and 89 public-sector units)[1]. The state of São Paulo, where the fieldwork took place, is the primary hub, concentrating 168 of these facilities. This figure places the country among the top ten worldwide in terms of the number of data centres.

Expectations for sector growth in Brazil follow global estimates. Mordor Intelligence estimates that the market in the country, valued at USD 2.95 billion in 2025, will reach USD 5.89 billion by 2030[2]. Brazilian growth is not unique, but rather symptomatic of the dispersion of this market beyond the Global North, which currently concentrates the vast majority of investments. This dispersion is driven not only by the search for new opportunities and more profitable investments, but also by the growing consumption of digital services—such as video streaming, financial trading, and autonomous vehicles—which require low latency (that is, the time it takes for a signal, packet, or instruction to travel through a system and produce an observable effect) in data transmission.

This growth does not come without problems. Alongside the capital invested in installing this infrastructure, there is an increase in the consumption of resources—most notably energy and

1 https://www.intercept.com.br/2025/09/17/moradores-se-mobilizam-contra-data-center-tiktok-ceara/

2 In Marx's work, alienation refers to the separation between the worker and the product of their labor, such that the former does not recognize the latter as the fruit of their effort. Moore's appropriation of alienation implies the estrangement of human beings from the natural processes that constitute them, both inside and outside their bodies and communities.

water—so that it is not uncommon for cities to face disputes between domestic consumers and their new neighbors[3], as in the case of Ireland. In countries whose energy matrix relies on fossil fuels, increased energy consumption places pressure on production, thereby increasing carbon emissions.

Between promises of sustainable growth and desires for exponential growth, the data centre market in Brazil is developing while attempting to balance environmental concerns and competitiveness. Supporting this effort is the country's large supply of clean energy, which not only reduces the price of this input but also positions consumers of this energy source within the carbon credit market. This would therefore amount to an alliance between the environment and the market, such that nature, once transformed into renewable energy, would be contributing to its own preservation, while humans—formerly its irrational predators—would now become its rational users.

This rationality is expressed above all in terms of energy consumption efficiency. The less energy is spent to keep a data centre operating, the more value is extracted from operational cost margins. Indeed, there is a metric that calculates exactly this: Power Usage Effectiveness (PUE). It is obtained by dividing a data centre's total energy consumption (roughly, servers and cooling equipment) by the energy consumed by servers alone. The more efficient the maintenance of an adequate temperature, the less energy is spent and, therefore, the closer the PUE value comes to 1. In this way, PUE functions as an index of a data centre's competitiveness, synthesizing environmental appeal with economic appeal.

PUE also makes it possible to infer climatic disadvantages among countries at different latitudes, which largely overlap with the socioeconomic and political inequalities between the Global North and the Global South. In other words, data centres in Global North countries—

3 As Hogan (2021) states, "The maintenance of a perpetual threshold helps the industry position itself as a technological fix rather than a solution in search of a problem" (284).

predominantly with cold climates—tend to spend less energy on cooling systems than data centres in temperate and tropical countries such as Brazil. Far from suggesting environmental determinism as an explanatory matrix for historical inequalities rooted in colonialism, PUE represents a supposed objectivity of numbers that, when detached from a critical approach, are merely variables indicating the return on investment of this type of enterprise.

If, for Brazil, the climate makes achieving a low PUE difficult, it is the same climate that provides the three main renewable energy sources that make up most of the country's energy matrix: hydroelectric, solar, and wind. These sources, in turn, can be used for the internal climatization of data centres at an economic and environmental cost that many Global North countries cannot afford. This arrangement makes climate an even more important factor, since the ongoing climate crisis puts at risk the predictability of natural cycles, both in their occurrence and in their intensity.

Thus, the relationship between data centres and the environments they occupy is marked by a fundamental ambiguity: while they are marketed as environmentally neutral, data centres are designed to protect themselves against increasingly common climatic contingencies. Precautionary measures, known in the data centre industry as "redundancy," include the use of backup energy sources in the form of diesel-powered generators. Indeed, during one of the visits made to a data centre, the guides reported that in the summer of 2023 it was necessary to turn on the generators. Their use, however, was not to compensate for a lack of power due to a possible supply failure, but rather to power the cooling system at a level that the primary energy system alone was unable to provide. This ambivalent relationship between infrastructure and the environment animates the initial reflections of this thesis.

But before delving into this conundrum, perhaps the reader is wondering: what is a data centre? The simple and incomplete answer is that data centres are buildings that provide the energy, climate, and connectivity conditions to host devices such as servers. This preliminary definition offers a familiar image (a building) and elements that, although somewhat abstract, refer to aspects of construction, such as air conditioning that maintains ambient temperature, cables for internet connectivity, and electrical wiring. Broadly speaking, data centres are buildings that keep powerful computers running and prevent them from overheating. However, couldn't a place with electricity, internet access, and climate control also describe a shopping mall, a university building, or a cold-storage facility? What makes a data centre specific?

Imagining Data Centres

The description in the previous paragraph takes shape in a certain type of representation of this infrastructure, common on data centre company websites. These typically include representations of both the exterior and the interior of a data centre. While the former is usually an aerial photograph of the site where the building is located, the latter is a representation—sometimes idealized—of corridors lined with server racks. It is in these corridors that the somewhat mundane magic of a data centre occurs, with servers running and expelling heat while cold air cools them. A powered computer and its airflow, however, do not produce a visually distinctive image. The invisibility of these processes is compensated for with symmetrical settings, straight geometric forms, and abstract spaces reminiscent of science fiction.

Understanding this imagery is a first step toward comprehending the sociotechnical processes that constitute a data centre. In her research on images formed from the architectural and

technical elements of data centres, Taylor (2017) proposes the notion of technoaesthetic, arguing that "the whitewashed surfaces of the data centre have a technical function but also an aesthetic (and therefore social, political, and historical) dimension" (43). This technoaesthetic, Taylor argues, enables a play of transparency and opacity across different layers of a data centre's operational space, concealing, for example, the grey space—that is, the equipment that composes the power and cooling systems—typically the unphotogenic back-end infrastructure. Thus, while proposing transparency through the production of these images, Taylor argues that "[w]hile the data centre industry continues to pump out 'behind-the-screens' footage of cloud infrastructure, that footage is always suspect, insufficient and concealing something else" (52).

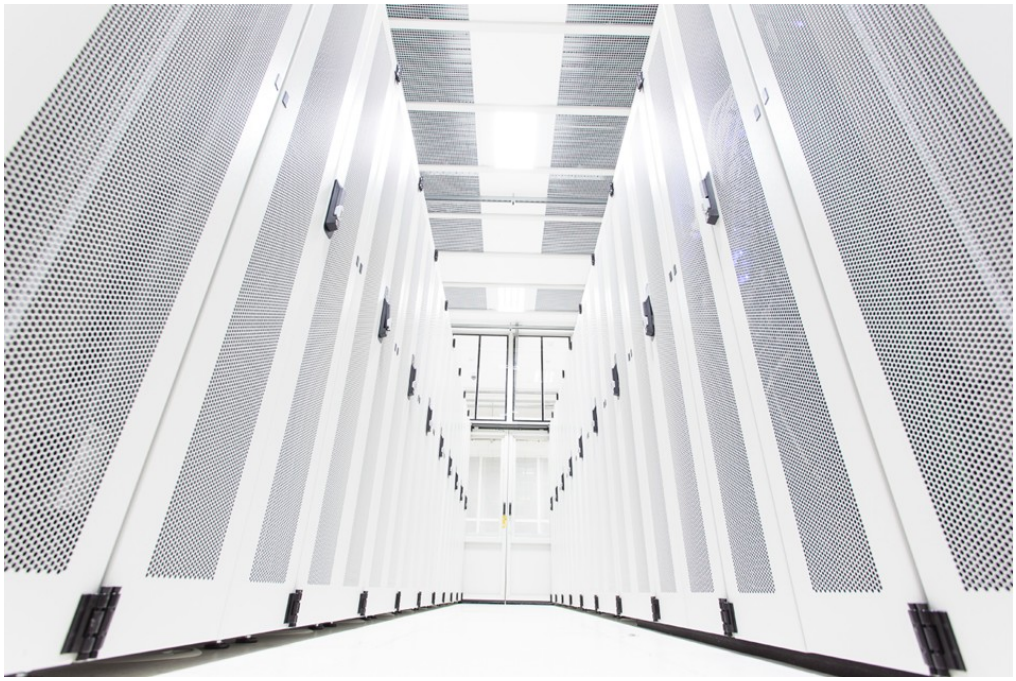


Figure 1: Server-cabinet corridor as canonical data centre imagery. From A. R. E. Taylor, "The Technoaesthetics of Data Centre 'White Space,'" *Imaginations: Journal of Cross-Cultural Image Studies* 8, no. 2 (2017).

Interestingly, Taylor also photographs these environments, meaning that the author's critique may also reveal the limitations of photography itself as a mode of representing a space whose visible movements are not tangible to human vision. However, there are other modes of representation that, even without the realism associated with photography, can reveal concealed processes. This is the case of Reynold Arnould, a twentieth-century French visual artist who produced works for industries in his country. Inspired by Cubism and Futurism, one of his most notable works, *Forces et rythmes de l'industrie*, used sketches from observation and industrial photographs to create works that moved from realism toward quasi-abstraction. In doing so, Arnould emphasized the flows of materials used in manufacturing processes and the movements of workers, leading critics of the time to recognize that he could restore a sense of "dignity" and *bel ouvrage* to workers who felt alienated by the anonymity of the assembly line (Rot and Vatin 2015). By abandoning pictorial realism, Arnould was able to make sense of productive processes fundamental to the French mode of production in the mid-twentieth century.

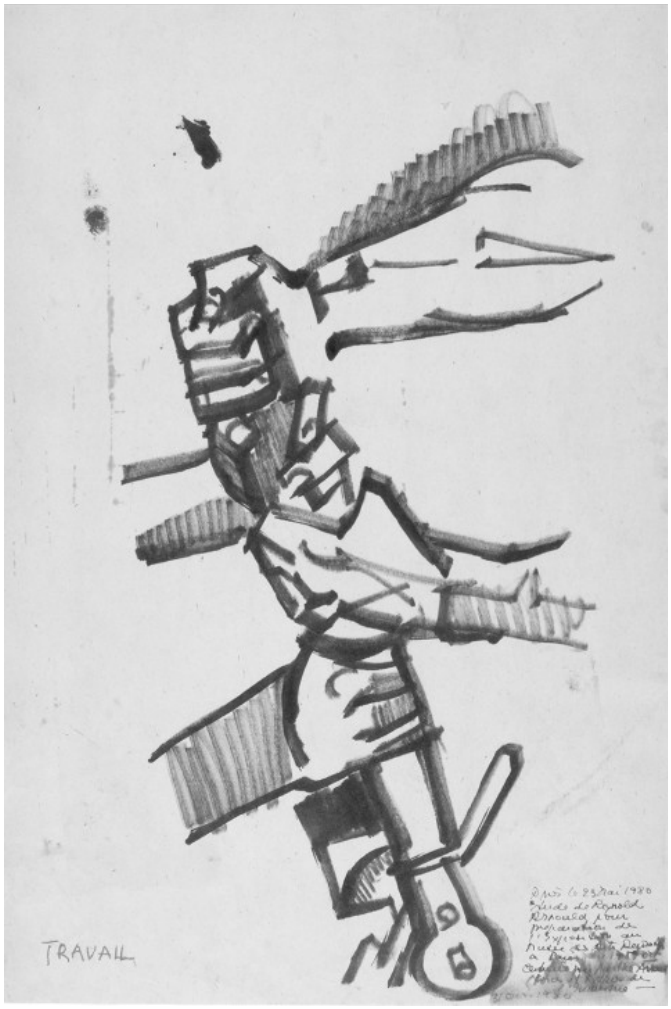


Figure 2: Work by Reynold Arnould. In Gwenaële Rot and François Vatin, “Reynold Arnould: un peintre à l’usine. Esthétique industrielle et mécénat d’entreprises dans la France de la Reconstruction,” *Artefact. Techniques, histoire et sciences humaines* 3 (2015).



Figure 3: Reynold Arnould, *Derrick*, c. 1958–1959, oil on canvas, 164 × 99 cm, Musée d'art moderne André Malraux (MuMa Le Havre), Le Havre.

Thus, Arnould's merit lies in employing a poetics that renders the human–machine relationship of industrial capitalism apprehensible. The movements of the human body and the material flows of machinery produce aesthetic enjoyment of labor, which in turn is exploited for the appropriation of surplus value. In this sense, even if Arnould may lack a

critical stance (after all, his patrons were the owners of the factories and plants he painted), his work has the merit of producing imagery around one of the main productive activities of his time, aesthetically re-signifying the technical dimension of its productive processes.

Comparing the photographer-researcher with the painter is not a veiled critique praising the latter over the former, since there is a technological gap between their contexts. If twentieth-century industry is visually accessible through the bodies and machines that compose it within a disciplinary regime, the machines and few people in data centres work with a set of materials intangible to the naked eye. This set, composed of the electrical current that powers machines and the heat that threatens them, can be understood as part of an entropic system. Before exploring the notion of entropy, which underpins one of the arguments of this thesis, it is useful to turn once more to an artist—this time one of the main figures of land art, Robert Smithson. His most emblematic work, *Spiral Jetty*, is a site-specific sculpture near abandoned oil rigs, made of basalt rock and "meant to interact with changing conditions of the surrounding water, land, and atmosphere" (Shapiro 2019).

Coincidentally, data centers must also contend with environmental variables, whether to protect themselves from disruptive events or to mitigate the externalities arising from their operation. Maintaining infrastructure stability in relation to the environment is one way of mitigating processes of material degradation. In contrast, by existing exposed to the elements, *Spiral Jetty* performs the opposite of a data center. Therefore, one might say that the work stands in contrast to a double process of ruination: that of abandoned human infrastructure and that of environmental erosion. In this way, entropy can be understood as the transition from a stable, organized state to one of chaos and noise.



Figure 4: Robert Smithson, *Spiral Jetty*, 1970, Great Salt Lake, Utah. Photograph by Charles Uibel / Great Salt Lake Photography. Holt/Smithson Foundation. https://holtsmithsonfoundation.org/spiral-jetty-0.

Entropy, however, does not occur only in the absence of human activity; it can also emerge and be accelerated precisely by certain human practices. As Smithson argues, "[t]he slurbs, urban sprawl, and the infinite number of housing developments of the post-war boom have contributed to the architecture of entropy" (Smithson 1966). Interestingly, by linking the production of human space to environmental composition in terms of entropy, Smithson's intuition approaches the idea of world-ecology formulated by Jason Moore (2011), in which the environment is not external to capitalism but part of it as an ecological regime—a totality encompassing both human and non-human materiality alike. Similarly, Smithson associates the capitalist way of life with entropy insofar as degraded urban centers and sterile suburbs become spaces for reproducing the consumer society he witnessed, such that "we find the discount centers and cut-rate stores with their sterile facades. On the inside of such places are

maze-like counters with piles of neatly stacked merchandise; rank on rank it goes into a consumer oblivion" (Smithson 1966).

The image of a consumer in oblivion can be understood as a metaphor for a state of high entropy, both in terms of a thermodynamic undifferentiation within a system, and in a cybernetic understanding, namely, the predominance of noise over signal. Spaces of pure consumption and uncritical reproduction of life function as ways of freezing the present, since the possibilities for counterpoint and disruption become reduced as objects of consumption management and control. The architectures that promote such management are materialized, among other forms, in the aisles mentioned by Smithson. This spatial organization, in turn, finds similarities with the environment of a data center, as shown in Figure 1. From a consumption standpoint, the corridors of a data center are hyper-aisles, since servers can store a much greater quantity of products for consumption, intensifying the consumer oblivion. Thus, while Smithson's comments refer to the dimension of consumption and social reproduction, the entropic process relevant to this thesis concerns value production in the data center as a sociotechnical apparatus. The entropy of a data centre lies in the degradation this technological ecosystem undergoes due to internal environmental variables such as heat and humidity. Maintaining these and other variables under control requires constant monitoring, such that the value produced by data centres lies in the molecular control and modulation of these variables. If American capitalism, as subtly denounced by Smithson, implies an intensification of entropy, the sociotechnical arrangement of data centres appears to operate in the opposite direction: reducing entropy becomes a condition for the appropriation of surplus value.

The next step is to understand the types of data centres. Readers who sought to understand what a data centre is before engaging with this thesis have likely encountered the websites of

companies operating in this sector. Beyond aerial images of vast industrial-like buildings and interior photographs depicting endless corridors of racks and servers, these sites usually present standardized definitions of data centre types and the services they provide.

One common way of categorizing data centres is by scale and power capacity. Hyperscale data centres are massive facilities designed to sustain global cloud platforms and process enormous volumes of data. They typically operate with power capacities above 10 megawatts, although some definitions extend this range up to 100 megawatts. These infrastructures underpin the operations of major cloud providers—often referred to as "hyperscalers"—such as Amazon Web Services (AWS), Google Cloud, and Microsoft Azure. At the upper extreme of this category are large-scale or mega data centres, which exceed 100 megawatts of installed capacity.

Data centres can also be classified according to their location and their relation to latency, that is, the time it takes for data to travel between users and servers. In this respect, physical proximity to end-users becomes a crucial variable. Edge, or micro, data centres are small, decentralized facilities installed close to users or data sources. Their primary function is to minimize latency—often to below 10 milliseconds—making them suitable for time-sensitive applications such as autonomous vehicles, high-frequency trading, and AI-driven voice assistants. By contrast, traditional or regional data centres are usually located near major metropolitan areas. They are designed to strike a balance between scale, cost efficiency, and acceptable latency for general internet services, such as cloud storage, content delivery, and enterprise computing.

Beyond differences in scale and location, data centres are also defined by the types of services they offer to clients. Colocation services allow customers to rent physical space within a facility, ranging from individual racks in shared rooms—often referred to as "retail"

colocation—to entire floors or dedicated data halls in so-called “wholesale” arrangements. For clients requiring higher levels of physical security, providers may offer enclosed cages or restricted-access areas. In addition to shared space, many operators provide dedicated resources, such as servers that are physically isolated and reserved for the exclusive use of a single company, ensuring greater control, performance, and security.

In this way, there is a correlation between the types of data centre use and their location. Facilities closer to urban centres benefit both from lower latency in the information they transmit and, according to one of my informants, from faster response times from their clients in the event of repairs. Hyperscale data centres, by contrast, since they perform computational tasks that do not require immediate connectivity—such as high-performance computing or the training of AI models—benefit from proximity to access to inexpensive energy sources and can therefore be located far from urban centres. This correlation is expressed not only in terms of synergies but also through power relations, since large-scale infrastructure projects invariably produce social and environmental impacts. Data centres are no exception. In addition to the Irish case mentioned above, there are numerous others, such as the construction of data centres in areas that already face high water demand, land grabs in rural areas and hinterlands.

Brazil: Challenges and Opportunities

This tension becomes even stronger when one takes into account the care demonstrated by data centre companies with the environment, particularly through the invocation of renewable energy consumption. In this regard, Brazil’s relevance is justified by its energy matrix, composed of hydroelectric plants, wind farms, and, to a lesser extent, photovoltaic panels. This alliance between infrastructure and environment can be thought in terms of

technonature, or a "part of a 'socio-physical process (...) through which symbolic formations are forged, social groups enrolled, and natural processes and 'things' entangled and maintained' (Swyngedouw 2007, 10). In other words, once integrated into the modern capitalist way of life, what we understand as nature can no longer be conceived as something non-human. Conversely, infrastructures do not operate according to a logic separate from culture; rather, they are in a constant process of co-creation.

Beyond expectations of economic progress and new employment opportunities that data centres promise, the consumption of renewable energy suggests a virtuous circle: the more renewable energy is consumed, the more value is produced with less environmental damage. Accordingly, the more data centres are built to consume renewable energy, the fewer greenhouse gases will be emitted. The world is saved, and the shareholders of these companies become richer. Everyone wins—or at least that is the message distilled in industry events and in the reports and promotional materials issued by these companies.

Concern for the environment is not merely a matter of CEO sensitivity or a marketing device, but a response to social and governmental demands regarding the responsibility corporations bear for their economic activities. These demands, in turn, have gained traction as the effects of environmental exploitation have entered common sense, both through everyday experiences of hotter days and less regular seasons, and through international scientific bodies that produce data attesting to the correlation between industrial activity and global warming. As infrastructures that consume "only" energy and water as raw materials, data centres are perceived as environmentally neutral, since their operation produces minimal waste. For data centres that rely on renewable sources, the relation with the environment is even more significant, as energy and water consumption becomes dependent on climate conditions, which govern hydrological and wind flows.

Added to this are the environmental issues that permeate public debate in Brazil, such as the chronic devastation of the Amazon for agribusiness and gold and oil extraction, the environmental disasters of Mariana and Brumadinho—two mining dams that collapsed, destroying cities and polluting rivers—and, more recently, the 2024 floods that affected the southern state of Rio Grande do Sul. For the purposes of this thesis, this latter catastrophe deserves closer attention. Unlike the mining disasters, which had legally implicated parties held responsible, the 2024 floods have no single, identifiable culprit: the rains occurred, the affected region had already experienced floods in the past, and climate change merely exacerbated a natural phenomenon. Beyond the governmental bodies responsible for prevention and for ensuring citizens' safety in the event of catastrophe, attempts at assigning responsibility oscillate between non-human actors, such as rainfall and a topography unfavorable to urban life, and human ones.

"Humans," this deceptively generic collective, have come to be regarded as a force of geological proportions under the label of the Anthropocene. As the name suggests, it designates a geological epoch in which humans have begun to affect the planet on a scale comparable to processes operating on more-than-human temporal scales. Amid debates about its onset and, consequently, about the agency of the Anthropocene (discussed in Chapter 2), it can be stated that the Industrial Revolution and the burning of fossil fuels play a role in this process. Data centres are neither outside of nor opposed to the Anthropocene, but rather a continuation of it, supposedly with the purpose of mitigating its effects. Ironically, in the case of the 2024 floods, despite deaths, destruction, and the paralysis of the state for months due to the reconstruction of housing and infrastructure, Scala, the country's largest data centre company, announced plans to build an "AI City." The chosen city had 90 percent of its territory destroyed by the floods.

Thus, as both infrastructure and business, data centres are doubly implicated in environmental issues: first, through their apparent environmental neutrality; second, through the climatic dependence of their operation. This second point is particularly sensitive given another characteristic frequently mentioned during fieldwork, namely that data centres are mission-critical infrastructures. In other words, they are expected to provide services without interruption. Because they house equipment that is sensitive to atmospheric and electrical fluctuations, ensuring uninterrupted operation requires not only a specific ethos for dealing with potential disruptions, but also the organization of machinery that guarantees redundancy at key points. A fundamental aspect of data centres, redundancy is something like a "Plan B" for their operation: it can be either backup equipment, in case the primary one breaks down, or a secondary system that can be activated if the first fails. The most notable example of this is the energy supply itself, which typically includes diesel generators to be activated when the primary supply is interrupted.

Supplementing power with diesel generators is one of the ways uninterrupted operation is guaranteed in data centres. These and other prevention systems entail additional expenditures in energy and equipment, which in turn generate more waste. It can therefore be inferred that the more mechanisms of redundancy and prevention of emergent events are put in place, the less sustainable a data centre becomes. Indeed, the very idea of redundancy is antithetical to efficiency. This reveals not only a contradiction between the discourse of data centre companies and their practices, but also a contradiction in the relation between this infrastructure and the environment itself. At the same time that coexistence with the environment is required for sustainability, data centres rely on resources that, insofar as they insulate them from the effects of extreme climatic events, also fuel processes that exacerbate global warming. This example of contradiction is illustrative in its immediacy, but, as will be outlined over the course of the thesis, the entire data centre production chain, including

energy and information infrastructures, operates through an ambiguous relationship with the environment.

This ambiguity constitutes the initial inquiry of this research. At first, it can be understood as instrumental rationality mediating processes of environmental preservation and capital accumulation. In this sense, the environment is simultaneously the material condition of social reproduction and object of extraction for the production of commodities. As infrastructures that both draw on the external environment and protect themselves from it, data centres end up creating an internal environment suitable for the efficient operation of the equipment they house. Thus, following Moore (2011), if the environment is to be understood not as a pristine nature but rather through the relationship between non-human nature and the hegemonic social relations of production in the world, it can be said that data centres constitute a micro-scale of a capitalist ecological regime. Another way to understand this proposition is by taking something that, for the modern subject, is nature in itself, such as a forest. If, within a nature–culture dichotomy, a forest is something separate from culture, then from a world-ecological perspective, as proposed by Moore, it should be considered as inseparable from other aspects that shape and influence its existence, such as logging companies, carbon markets, and other activities that turn it into a commodity. Conversely, the same can be said of data centres: as they are built to house servers and other digital equipment, they make use of technological equipment, investment funds, and specialized workers para a modulation of flows of air, energy, water, and other elements, being an environment in its own right.

But how is this climate produced? How do the managers of these environments understand the sociotechnical assemblages they oversee? Are extraction, primitive accumulation, and the

expropriation of surplus labor sufficient to explain capital accumulation in this infrastructure–environment articulation?

Thesis Organization

To answer these questions, the thesis is divided into seven chapters. The first one situates the understanding of data centres within the materiality of infrastructure and the environment. Leigh Star (1999) and Brian Larkin (2013) provide the conceptual foundations for approaching infrastructure, while authors and topics that deal more directly with data centres —waiting and temporality (Burrell 2020), technonature (Levenda and Mahmoudi 2019), thermal cultures (Vonderau 2019; Starosielski 2015, 2021), infrastructural mobility and precarity (Velkova 2019)), and carbon fungibility (Pasek 2019)—address the socio-environmental aspects of data centres. These authors allow me to define the object (data centres and their techno-ecological relations) in the Brazilian context. It also maps questions of political economy of the environment and entropy. This is where the central thesis is proposed, namely that data centres follow an economic logic that is not comparable to extractive or manufacturing industries. This logic begins with the extraction of human and non-human nature (Moore 2015, 2015), but the value produced lies in the control of their internal environment, that is, entropy. This is a key concept in my argument, as it connects both the paradigm of entropy as the amount of heat in a closed system and the amount of information in cybernetic systems. A data centre deals simultaneously with these two notions of entropy. Finally, it proposes hypotheses about modes of value generated in data centres. I draw on the idea of economization, developed by Koray Çalışkan and Michel Callon.

Chapter 2 offers a preliminary approach to data centres through the discourse their companies mobilize about the environment. To this end, it analyzes ESG reports, which account for

environmental and social aspects impacted by companies. To do so, it situates these reports within Anthropocene discourse, analyzing the contested meanings of this geological era and pointing to the interpretation most relevant to the thesis. Moore's understanding of the Capitalocene enables me to articulate the environmental crisis on a geological scale with the capitalist mode of production. Then, the chapter engages with works that articulate temporality and environmental crisis. Bond and Liboiron offer perspectives that help me think through ESG reports. However, the environmental relations mediated by data centres differ from those produced by the oil industry. At first glance, data centres appear environmentally neutral. I show that the reduction of the environment to quantities that are exchangeable across different types of value (money, carbon, watts) follows the same logic as the discourses addressed by Bond, and entails a form of violence in pollution management analogous to that exposed by Liboiron.

Chapter 3 details my efforts to enter the field and relate to its agents. I draw inspiration from Burrell to develop a strategy for accessing data centres by mapping their points of connection, both institutional and social. By pursuing different paths toward this goal, I meet people and engage them in dialogue about the topics of my research. The chapter narrates several events in which I participated. I argue that the imaginaries articulated by industry players (people with significant influence in the sector) are not mere ideologies that mask reality, but simulacra that make sense within the regime of signs in which they are embedded. This meaning is reinforced by techniques and a worldview (modern-capitalist) that quantifies and prices everything. This approach unfolds into other aspects that compose the sociality of these actors, such as issues of race and gender.

It is also in this milieu that I encountered a type of magnitude that appeared several times during fieldwork: the infinite. In the context described in this chapter, it does not appear fully

as such, but rather in a manager's desire for the exponential growth of the sector. Even for a type of infrastructure marketed as environmentally neutral, this kind of growth points to the metabolic rift, as elaborated by John Bellamy Foster (2000).

Chapter 4 explains how clean energy is conceptualized and produced. Its production entails the destruction of ecologies and people, such that the state (whether a dictatorship or a liberal democracy) acts in alliance with the market. This destruction paves the way for an ideology and a mode of life based on technological and material progress, which modern subjects such as this author enjoy and are unable to live without. I then explore one of the central metrics used by data centres to measure their growth: the watt. Broadly speaking, I show that the watt is nothing more than a measure of work. Through this measure, human labor becomes abstracted as a driving force and equated with the kinetic movement of wind, rivers, and steam (set in motion by the heat of combustion or radioactivity), or of the sun. These reflections are articulated with discourses produced by people encountered during fieldwork on different occasions: during my visit to Peekaboo Telecom, at the ABDC energy panel, and in the account given by Thomas, one of my interlocutors.

Chapter 5 demonstrates the socio-environmental dimension of informational infrastructures. I do this in order to challenge the idea that the materiality of digital information (bits, waves, light) is ecologically neutral. On the contrary, it is both a condition for and a medium of the advance of the modern machine of progress. This, however, is not only bad news: it also brings possibilities for social change, as was the case with Brazilian slavery. In this sense, the chapter traces a history of information infrastructures that predate the internet but exert a spectral influence on contemporary connections. I then analyze my interlocutors' accounts of the difficulties of maintaining internet infrastructure in both urban and forest contexts. In both settings, the dynamics of these places generate points of risk emergence which, for

infrastructure operators, are reduced to noise. Thus, different regimes of signs (such as those of the Nambikwara people) and of matter (winds, trees, arrows) compose possibilities of struggle and resistance around telegraph and fiber-optic cables. Finally, the chapter concludes with a reflection on a mode of value speculated by Andrei. Infinity, which was hinted at by the agents in the previous chapter, reappears unequivocally in his speech, opening a path to thinking about value beyond the capitalist economic order.

Chapter 6 explores the materiality of computation through the environment required for it to take place. In this way, the aim is to move away from the idea that computation is an activity that is somehow immaterial, or whose materiality is limited solely to the technical objects that make up a system. On the contrary, from the fabrication of integrated circuits to massive data centres, the production of an atmosphere and of ways of managing flows of energy, heat, and people is fundamental. Thus, there is labor distributed between humans who manage and operate these sites and the sensors, switches, and machines that automate the regulation of these spaces' parameters. In other words, one must consider computation in tandem with the environment required for this activity. This control aims to minimize entropy, which can emerge without warning, as was the case with Unicorn Data Centres, which suffered a fire weeks after my visit. To do so, the chapter describes the surveillance and control technologies of these sites, drawing on Tung-Hui Hu (2015), and Anne Kaun and Fredrik Stiernstedt (2023). By generating information about themselves (rack door opening reports, downtime duration, heat variation), it becomes possible to understand that the value produced in data centres is the flattening of the future into a constantly predictable present. From this, one can reflect on the kind of temporality these infrastructures put into operation, both through an eternal present and through exponential growth, and the infinite value of information and of the exploitation of nature.

Accordingly, the chapters describe the sociotechnical processes of a data centre as an infrastructure that articulates information and energy to produce value. They also examine the subjectivity of the agents who operate this type of infrastructure and how they conceptualize the environment in terms of the technologies they manage. Based on the findings developed in these chapters, the conclusion proposes an understanding of the economy and temporality that emerge from this infrastructure, as well as a psychic dimension of the subject who operates it.

The first step in this argument is to think of data centres as entropy-management machines, both in a thermodynamic sense (the transformation of energy into work and heat as waste) and in an informational sense (the capacity to preserve meaning in information). In thermodynamic terms, data centres are structures that must dissipate the heat produced by their equipment while simultaneously transforming energy into cooling. They are not steam engines—the artifact that underpins thermodynamics—but rather systems whose operation depends on separating elements such as water and air according to temperature. In this sense, the data centre, as a thermodynamic system, produces order by thermally differentiating distinct airflows.

In informational terms, entropy can be understood through the frameworks proposed by Claude Shannon and Norbert Wiener. For the former, information is that which has the potential to alter the state of a system when decoded (high entropy); for the latter, it is an index of order in a message (low entropy). Although they propose distinct formulations of entropy as a notation of order, both Shannon and Wiener understand information as something that produces a difference within a system, provided that the system is sustained by order. Differentiation within a system—that is, the possibility of the new—may entail the emergence of risk or the continuation of its operation. It is precisely the control of this

environment, through the production of information about itself, that enables the maintenance of its order. Thus, if Wiener argues that information and entropy are dynamic processes —"[i]nformation and entropy are not conserved, and are equally unsuited to being commodities" (1989, 116)—one of the conclusions of this thesis is that data centres succeed in transforming and "packaging" low entropy into what I propose to call "Climate as a Service." I suggest that this regime may mark the beginning of a new sociotechnical paradigm in a world whose environment is becoming increasingly and irreversibly hostile.

The production of climate as a commodity can be understood as one of the frontiers contemporary capitalism is able to cross, particularly in light of the ongoing degradation of the global environment as a common. This political and economic consequence carries with it another, equally unfortunate. The environment, as an openness composed of different agents (including those that constitute capitalism), possesses an open temporality. The climate crisis is an unintended consequence of the emergence of new energetic and material interactions, triggered or accelerated by the extractivist and manufacturing practices of capitalism. In this sense, the intensification of extreme phenomena generates destruction and an environment inhospitable to life (i.e., chaos or entropy). A temporality of undifferentiation entails the interruption of the actualization of possible futures. Conversely, as infrastructures dedicated to maintaining their internal climate, data centres produce value by narrowing multiple possible futures into the single one that matters to their clients.

Thus, this thesis takes entropy as its explanatory key for understanding data centres as infrastructures that bring computation and the environment together to produce value. To address the three distinct senses of the concept, I adopt a theoretical framework situated between the Marxist critique of the environment and technology, on one side, and authors who explore the reciprocity between society and technology, on the other. This allows me to

grasp the historical and material development of digital infrastructures in contemporary Brazil, interwoven with the symbolic and cultural fabric of the people behind them. Above all, the framework emphasizes the interplay between the technological arrangements that make up human reality and the capacity of human agency and imagination either to produce a new reality or to reinforce the existing one.

Notes on AI

Throughout this thesis, the reader may have noticed an insufficient emphasis on AI. This impression is justified, since, following the fateful November 30, 2022, with the launch of OpenAI's ChatGPT, the world has never been the same. This inflection point occurred across virtually all spheres of life, and in the world of data centres it was no different. In nearly every moment of fieldwork, AI was present in some form. This presence manifested in different ways. In one, it resembled a messianic being from the future, whose promise to its subjects demanded an infrastructural and energetic offering. In another, it appeared as a reality for companies that already had it as a product, such as Nvidia. In still others, AI was mentioned as a complement to existing services, something like an item on a checklist to make a service more attractive. This omnipresence makes the author's decision to relegate AI to a background element all the more curious.

This stance is not justified by naïve technophobia. On the contrary, it is necessary to accept the emergence of a technology through the contingency that constitutes it. In the case of AI, some vectors of such contingency include: the surplus of data used to train models, produced through precarious labor on platforms such as Amazon's MTurk; the discovery that GPU architecture, previously used primarily for rendering 3D models, could be repurposed for deep learning algorithms; fiber-optic networks that enable high-speed data transfer; and the supply of electricity, whose price made economically viable (though not necessarily

profitable) the operational costs of products such as OpenAI's ChatGPT or Microsoft's Copilot. Data centres are therefore the place where these elements converge, housing GPUs, powering them with purchased electricity, and connecting them to the internet and corporate computer networks.

Taken in this way, the phenomenon of AI can be compared to another event whose beginning promised to be an inflection point for humanity but is now relegated to certain niches. I refer to blockchain technology, which during the 2010s was presented as highly disruptive, capable of rendering the global financial system obsolete and, through cryptocurrencies such as Bitcoin, producing spaces of monetary sovereignty independent of nation-states. The technology behind this promise, Proof-of-Work, would transform computers into transaction-verification machines, incentivized through fractional monetary rewards (known as mining), thereby producing an incorruptible ledger. Mining, in turn, is energetically costly, and during the hype period surrounding Bitcoin and other blockchain technologies, a gold rush emerged toward regions with cheap electricity and, preferably, loose regulations. Even without a convincing use case comparable to what we see today with AI, there are still places and enthusiasts who, driven by the greedy hope of a cryptoutopia, dedicate hardware and electricity to this activity.

The loss of blockchain's prominence to AI occurred while the search for energy sources remained the same. Hardware demand is similarly comparable: whereas Bitcoin miners benefit from dedicated chips, AI data centres depend on GPUs. When commenting on architectural specificities in turnkey data centre projects, a sales manager I interviewed stated that Nvidia kept the market hostage to an at times brutal pace of innovation: according to her, Nvidia's schedule for releasing new GPU models is increasingly accelerated. As a result, there are waiting lists lasting months for companies ordering large quantities of these cards.

This rhythm of “programmed innovation,” she argued, makes it increasingly difficult to formulate hyperscale data centre projects, since it becomes necessary to anticipate the type of product or service to be developed in order to justify a technology that will only be released months later.

Nvidia’s preponderance, in turn, raises questions about the fragility of the economic ecosystem behind AI. Since late 2025, there have been suspicions that the market value of the main companies sustaining this ecosystem (Nvidia, OpenAI, and Oracle) is inflated by a form of accounting sleight of hand, in which the same money is counted more than once across different intercompany contracts. Furthermore, like Uber, which has accumulated multiple financial quarters at a loss, the economic viability of products launched by OpenAI remains uncertain. Thus, the bullish stance of my interlocutors regarding the alliance between data centres and AI may have the same consistency as the financial capital backing this technology.

This skepticism, however, is not directed at AI as a technology per se, but rather, as outlined above, at the elements that compose the specific configuration of AI as part of a data centre infrastructure. In other words, if OpenAI and its Western competitors were to shut down, the technology would still exist in forms such as DeepSeek, a Chinese AI developed during the GPU shortages the country experienced in the early 2020s. Its model-training architecture therefore requires fewer computational resources, making it less energy-intensive. Moreover, DeepSeek is an example of open-source AI that can be installed on personal computers (provided they have minimal computational capacity, namely a GPU), making it possible to imagine alternative uses of artificial intelligence not dependent on infrastructures such as data centres.

One consequence of this is that differences in scale and concentration of computational labor may slow the exponential growth of the data centre market. In other words, the possibility of local access to a large language model, without mediation by a data centre, offers a way to think about AI without data centres, that is, a line of flight from the narrative that was consistently presented to me during fieldwork. This does not change the extractivist dynamics of mineral and energy exploitation, but it does alter the capacity for agency in this context, since AI ceases to be a technology maintained behind large-scale infrastructure and becomes something that can be appropriated individually or collectively. In this sense, one may speculate whether the massive purchase of components such as RAM, processors, and GPUs by technology companies and data centres constitutes a movement toward the concentration of computational capacity, anticipating the possibility of losing monopoly control over this type of technology.

Chapter 1 - Literature Review

Introduction

This chapter reviews the literature with which this research engages. It begins by addressing canonical authors in the Anthropology of Infrastructure. It is through Susan Leigh Star and Brian Larkin that a critical approach to infrastructures becomes possible, since they reveal the political and social aspects that compose these technical apparatuses. Even if indirectly, the authors in the next section — which can be called "Data Centre Studies" — are indebted to the work of Leigh Star and Larkin insofar as they treat data centres as an infrastructure that affects the environment, the people who live in it, and the infrastructures on which they depend. The chapter seeks to dialogue with authors such as Mel Hogan (2017, 2021), Jenna Burrell (2020), Anne Pasek (2019), and Anthony Levenda (2019), insofar as these authors raise important questions for approaching data centres. These works, however, are situated mostly in the Global North, which makes it necessary to adapt their contributions while taking into account issues specific to the place where the fieldwork was conducted.

The other sections explore authors who help ground the central argument of this dissertation, namely, that data centres are sites where an economic regime based on entropy emerges. Such a regime not only transforms nature (heterogeneous and continuous) into the digital (homogeneous and discrete), but also produces imaginaries and technological assemblages of the environment. To develop this point, the work of James Moore and John Bellamy Foster provides the theoretical framing of a particular form of environmental exploitation under capitalism. In the context of data centres, this exploitation takes on specific characteristics that make it necessary to engage authors who deal with digital infrastructures, such as Tung

Hu, Anne Kaun, and Fredrik Stiernstedt. These authors show how digital technologies affect regimes of institutional control and discipline, such that data centres and prisons display relevant points of convergence. Finally, this review addresses the anthropology of value, particularly the work Koray Çalışkan and Michel Callon.

A preliminary definition of a data centre can be sketched from the websites of companies in the field. On their main pages, two image patterns are commonly found. The first consists of an aerial view of a plot of land occupied by a building, power generators, and, less frequently, a power substation—suggesting a self-contained space, detached from its surroundings. The second pattern features photographs taken inside these buildings, between rows of server racks forming corridors. There are usually no people in these photographs, suggesting autonomous operation. Thus, one can infer that data centres are safe spaces, protected from two sources of risk: environmental externalities and the unpredictability of human agency.

These ideas, however, conceal the technical relations that these infrastructures establish between people (both those who operate and those who serve them) and nature (both the one that precedes them temporally and the one that follows them culturally). People and nature, in turn, are not confined within the spatial boundaries of the images but leak and proliferate beyond them. Indeed, to approach infrastructures is, among other things, to recognize the intertwining of social and technological logics that shape these relations. Ultimately, these authors offer the concepts that help me develop this thesis's main hypothesis, namely, that data centres—being infrastructures highly dependent on the environment—end up producing it. This production entails specific modes of exploiting human and non-human nature, as well as forms of value derived from energy and information (computing). Thus, computing cannot be understood as a purely technological operation, but also as an environmental one, involving the control of the internal entropy of these infrastructures. Finally, the agents who

work within these infrastructures articulate discourses and construct imaginaries around temporality, technology, and nature, often in contradictory ways.

Anthropology of Infrastructure

A fundamental field for beginning this discussion is the Anthropology of Infrastructure. With Susan Leigh Star as its main author, this field proposes approaching infrastructure through its relationality (1999, 380)—that is, infrastructures are best understood by examining how they shape and are shaped by the beings they affect and that are affected by them. Leigh Star proposes that infrastructures have the following properties: a) embeddedness; b) transparency; c) reach or scope; d) learned as part of membership; e) links with conventions of practice; f) embodiment of standards; g) built on an installed base; h) becomes visible upon breakdown; i) fixed in modular increments (381–2).

The purpose of this enumeration is not to establish a "checklist" of what constitutes an infrastructure but to draw attention to the effects that are not immediately apparent in such objects. In this sense, one might propose that data centres depend on fiber-optic cables and a stable supply of electricity (a), which leads to planning their construction near energy sources, or at least within a power distribution network (g). Furthermore, we do not notice their existence when we access our email (b), but we are forced to think about how they exist and why they fail when we cannot access our inbox (h). These are just a few of the ways of understanding that *Ethnography of Infrastructure* allows, and its influence will be felt throughout the course of this literature review.

A close interlocutor of Leigh Star, Brian Larkin is also an important author for approaching infrastructures through anthropology. His article *"The Politics and Poetics of Infrastructure"* (2013) continues Leigh Star's project by proposing questions that articulate the symbolic,

technical, and political dimensions of infrastructure. In his reading of Foucault (2010), Larkin (2013) understands that infrastructures "reveal forms of political rationality that underlie technological projects and which give rise to an 'apparatus of governmentality'" (328). In this way, technical discourses and practices, even when performed in a self-referential manner, express "forms of desire and fantasy and can take on fetish-like aspects that sometimes can be wholly autonomous from their technical function" (329).

Moreover, Larkin argues that ethnography dealing with infrastructure requires a "retooling," such that fieldwork must focus on places and people "conducted in government centres far from where the actual roads are constructed and might take into account politicians, technocrats, economists, engineers." This contribution resonates with a shift already underway during one of the discipline's crises, when George Marcus argued that an ethnography engaging both the global and the local must attend to the "logics of relationship, translation, and association among these sites" (1995, 102). In this sense, discourses articulated in places far removed from data centres, as well as sites of training and curriculum development for professionals in the field, can be as important as the observation of data centres themselves.

Finally, it is also through the *poetic dimension* that the diverse materiality of this infrastructure performs—through its documents, its noises, its technical organization, and the speech acts that allow for the analysis of form independent of technique, that is, when a speech act "is organized according to the material qualities of the signifier itself rather than to its referential meaning" (Larkin 2013, 334).

Data Centre Studies

Data centres are a relatively recent type of infrastructure, making them a new object for Anthropology and Science and Technology Studies. Nevertheless, there is already a growing body of interconnected research, making it necessary to understand the approaches being taken and the key questions shaping the field.

As large-scale projects that sometimes take years to complete, infrastructures provoke projections and desires about futures they may help, accelerate, or make possible. In this sense, the people who build, operate, and maintain them—as well as those who use them or are affected by them—produce discourses that imbue them with meaning, whether to justify or to contest them. My interlocutors, all workers or managers of data centres, articulated discourses that endorse the existence of their workplace, even while recognizing the inconsistencies within the hegemonic and official narratives of companies in the sector. Residents of a region where TikTok plans to install a data centre, on the other hand, are aware of the environmental cost of such an endeavor and have mobilized against it[4].

These two groups of subjects—the proponents of data centres and those who resist them—represent instances of infrastructure that are not explicit. The discourse of managers and CEOs who contributed to the fieldwork does not justify data centres as an end in themselves, but rather through economic imperatives, the necessity imposed by demand, and the progress always promised by new technological trends. Drawing on Collier (2011), Larkin argues that an anthropology of infrastructure consists of "an ethnography that produces different

4 The Agile methodology was a response by software engineers to the previously paradigmatic software development models—considered inflexible and limited in delivering products that satisfied clients—such as waterfall. It is composed of the following principles: "Individuals and interactions over processes and tools / Working software over comprehensive documentation / Customer collaboration over contract negotiation / Responding to change over following a plan." These principles reveal not only a desire for post-Fordist modes of work organization and work ethics (Boltanski and Chiapello 1999), but also an imperative grounded in functionality.

infrastructural objects, where the budget as a site of formal rationalization is as important as the brute material of technological systems" (2013, 332). In this thesis, special attention will be given to ESG (Environment, Social, and Governance) reports as a specific type of formal rationalization.

By articulating infrastructure and environment, Mel Hogan's work helps to critically problematize modes of valuation in data centres insofar as they are infrastructures that facilitate the implementation of a political economy that is extractive both in relation to the environment and other infrastructures, and in relation to the users who depend on them. Data centre companies and related enterprises are characterized by an ambiguous relationship with the environment, since, while they claim to promote a partnership through the sustainable use of natural resources, they end up enslaving it through the exhaustive consumption of water and energy. According to Hogan, this contradiction is symptomatic of the neoliberalizing logic that inserts nature and humans alike into the instrumental rationality of the market (2018, 635). Although the logic of capital accumulation is the driving force behind this problematic development, Hogan points to an internal logic of the digital economy—particularly in data centres—in which data is a currency through which the entire infrastructure of the internet expands (2018, 2021).

This insight is developed further in *"The Data Center Industrial Complex"* (2021). In it, Hogan argues that the power and knowledge potentials embedded in data require researchers to "pay attention not only to the redistribution of wealth and resources afforded by data infrastructures but also to the logical embodiments of the process it inspires and imposes" (286). Such processes are not confined to the infrastructure of a data centre but extend down to the individual level—as in smartphones, Wi-Fi-enabled refrigerators, and autonomous cars. Thus, data can be considered raw material for an economy grounded in granular

governmentality, as anticipated by Deleuze (1992). It is through the proliferation of data that the demand for data centres is justified, such that “data is the currency that pays for the development of Big Tech infrastructure, which in turn determines the worth of the data” (Hogan 2021, 285). In this way, there exists a logic of value production internal to data centres, but one that depends on extractions external to them—whether in the form of data or natural resources.

Furthermore, drawing from Hogan’s work, one can preliminarily approach data centres as a “relational assemblage” (Edwards, Cooper, and Hogan 2024)—that is, “materializations of particular power relations and imaginaries” (430), or “a constantly shifting assemblage of relationships, objectified in particular ways, in particular places” (433). This allows me to think of the data centre through its materiality, without reifying its technical arrangements or the beings it consumes and serves. Instead, materiality can be taken as both support and agent —capable of provoking imaginaries and struggles out of its own potentialities. In this sense, data centres are concrete sites that engage with local topologies and environments but are also nodes within a network topology that abstracts local affordances in the form of energy, information, and value—placing them into flow within the global market.

The resistance of groups affected by data centres and their adjacent infrastructures is an example of rupture within the discourse of technological progress. This rupture typically reclaims the material means of existence when they are threatened by water-thirsty data centres or wind turbines that disturb the psychic well-being of nearby residents. Such struggles are significant because they reveal a disbelief in the promise of development, as already described by Burrell (2020). The author proposes analyzing data centres through a temporality that begins before they become a completed assemblage—that is, during the waiting period of their implementation. She conceives of waiting as “a particular rhythm of

material unfolding, often one that is slower than expected or desired" (2020, 286). Although the fieldwork conducted for this research focused only on data centres already in operation, waiting as a rhythm is cynically felt as frustration toward a future that never arrives.

In *"The Field Site as a Network: A Strategy for Locating Ethnographic Research"* (2009), Burrell raises important questions about how to rethink field and culture during ethnographic research. In this article, she proposes conceiving of the field as a heterogeneous network composed of fixed and moving points, including people, objects, and spaces, integrating physical, virtual, and imagined domains. Many of her suggestions—such as seeking *entry points* into the field and *following*, but also *intercepting* key individuals—were adopted for this fieldwork and will be detailed in the chapter dedicated to it.

To problematize the environment on which life depends highlights the porous boundary between infrastructure and what moderns understand as nature. A data centre in Sweden will have different climatic affordances and challenges from one in Brazil. In this sense, the planning, construction, and maintenance of these infrastructures are not carried out *in spite of* nature but *alongside* it, such that data centres "are not just social, technical, or ecological. They are all of these at once" (Levenda and Mahmoudi 2019, 5). Following Swyngedouw (2007), the authors propose that infrastructures such as dams and data centres are *technonature*. More than a neologism, this term enables us to think of infrastructures as something beyond external agents to an environment, undoing dichotomies that, by opposing nature and culture, may prove counterproductive. On the contrary, for the authors, "[e]xisting technical infrastructures demonstrate the ways in which society rationalizes, controls, and connects natures," such that data infrastructures are both the expression and the production of nature and culture (6).

According to the authors, this articulation between society, technique, and ecology has digital capitalism as its driving force, one that reshapes the relations between the urban and the rural (9), while also producing new dynamics of inequality and capital accumulation—such as the proliferation of infrastructural layers that support data centres, and the extraction of value from both human and non-human agents. These new extractive dynamics lead the authors to question what is driving the growth in digital capitalism and how this growth reshapes both the urban and the rural (10)—a question that reverberates throughout this research.

A similar approach is taken by Vonderau (2019). In addressing the ways in which airflows are engineered in the data centre industry in northern Sweden, she argues that cloud infrastructure—a specific modality of data centre—"is not only a calculatory, but also atmospheric and bodily process" (6). She draws attention to the thermal dimension of this infrastructure, engaging with Starosielski (2015, 2021) on the racial, gendered, sexual, and colonial aspects that emerge from the articulation between culture and heat. These *thermocultures*, as termed by Starosielski, not only exploit local climates for cooling but actively reshape them through infrastructural practices that link environmental conditions to technological demands. Most importantly, it is through the sociotechnical relations operated within these infrastructures that bodies, energy, and heat are mobilized under the scrutiny of capital.

This geographic and atmospheric embeddedness is mirrored in Julia Velkova's analysis of data centre mobility. In her *"Data Centers as Impermanent Infrastructures"* (2019), she highlights an apparent ambivalence in data centres: while they are infrastructure, they are also modular and transient in character. Such ambivalence arises from the rhythms of innovation and obsolescence inherent to digital technology, as in the case of Nvidia GPU boards, whose release cycle is approximately two years. Additionally, their ease of disassembly enables

cloud companies to exploit economically vulnerable regions as temporary nodes of value extraction, allowing "a new dimension of economic precarity, in which the jobs that data centers facilitate are as short-lived as their life-span" (5).

This logic of mobility is underpinned by corporate strategies of fungibility. Beyond their productive and "clean" character—measured in energy consumption and data processing capacity—data centres are also part of the carbon flow they generate within their own metabolism. Thus, Anne Pasek, in her *"Managing Carbon and Data Flows: Fungible Forms of Mediation in the Cloud"* (2019), introduces the concept of *fungible mediation* to describe how companies like Microsoft Azure abstract local ecologies and labor relations into globally tradable commodities. This logic of abstraction, exemplified by Renewable Energy Certificates, allows companies to exploit the resources of the locations they occupy while offsetting emissions through investments and emission reductions elsewhere—achieving, albeit controversially, a net-zero carbon balance.

In *"The World Wide Web of Carbon: Toward a Relational Footprinting of Information and Communications Technology's Climate Impacts"*, Pasek, Vaughan, and Starosielski (2023) address the debate surrounding quantitative research on ICT's global carbon footprint. To do so, they map different positions on the relation between the growth of digital infrastructure and the carbon emissions it produces. They criticize both the "optimistic" position—where ICT's growth is largely decoupled from its carbon emissions due to technological efficiencies (as suggested by Moore's Law/Koomey's Law)—and the "pessimistic" one, which claims that ICT's global carbon footprint will increase dramatically, potentially requiring urgent regulation and sectoral degrowth.

Instead of siding with either position, the authors point to fundamental methodological issues within this dichotomy, such as incomplete access to industry data and regional inequalities

obscured by metrics like KWh/GB. This leads them to propose a *relational footprint* approach, allowing for the identification of "specific differences between discrete and measurable local elements and [suggesting] how these differences might be leveraged for climate mitigation" (9). They therefore reject an environmental critique and policy framework that, by flattening regional differences, ultimately reproduces a market-based perspective. The analytical framing of this dissertation is partially inspired by this local delimitation of the "constellation of data centers, cables, and internet exchanges" that enables a critical assessment of Brazil's climate crisis.

The questions raised by Pasek, Velkova, Vonderau, Levenda, and Burrell are mostly situated in the Global North, in regions with cold climates. Despite the specificities of each author's field site, it can be said that the countries where their fieldwork took place all share a postwar economic growth context, fueled both by the direct or indirect exploitation of the Global South and by the intensive use of fossil fuels. In this sense, data centres can be seen as a post-industrial promise of maintaining former wealth and prosperity—even if, in practice, they function as neoliberal agents within the global market. This market renders different places—each with its own climatic, infrastructural, and social specificities—equivalent under the metric of potential costs and returns.

Thus, the questions posed by these authors remain relevant, since data centres are traversed by meta-organizations, such as the International Standard Organization and Uptime Institute, that shape "the performance and calibration of many components of infrastructure space at every scale, from the microscopic to the gigantic" (Easterling 2014, 171). At the same time, the processes of construction, operation, and maintenance of this kind of infrastructure are negotiated according to local climatic, economic, and cultural variables. The works of these authors, therefore, help frame the object of this dissertation, while the specificities of the

fieldwork conducted allow me to respond to their questions and propose new ones aligned with their contributions.

During fieldwork, most of my interlocutors were CEOs and managers of data centre companies and related firms. They are the ones who plan the business and growth strategies of the organizations they work for. *Business* and *growth*, in turn, will be taken here in their deeper sense—beyond mere commercial activity. The former refers to processes of framing people and nature in economic terms (*economization*, to be detailed later), while the latter will be analyzed in terms of how this infrastructure transforms energy, information, and labor into value. Thus, the second group of authors and theories relevant to this literature review connects the *Anthropology of Science and Technology* with *Political Economy*, emphasizing the sociotechnical relations that take place within data centres and the metabolism that arises from them.

Political Economy of Environment and Entropy

The starting point of this stage of the literature review is the work of Jason Moore. More specifically, what interests me in his contribution is the articulation between processes of capital accumulation and the climate crisis. This articulation allows for the association of two critiques that are often treated separately: the cyclical crises of capital accumulation due to the exhaustion of surplus value appropriation (the *economic limit*), and the exhaustion of natural resources for productive activities (the *ecological limit*). The first, anticipated by Marx, concerns the development of productive forces through investment in fixed capital—especially industrial machinery—which increases productivity at the expense of decreasing labor employment. The second, exemplified in *The Limits to Growth* (Meadows, Meadows, and Randers), questions the exponential growth presupposed by capitalism in the face of

finite natural resources, especially given the pace of environmental destruction that exceeds regenerative capacity.

This mismatch between the rhythm of capital accumulation and the rhythm of the reproduction of human and extra-human natures is understood by Moore and his Marxist interlocutors as a "metabolic rift." Thus, there is a dialectical relation expressed from different angles—whether through rural–urban relations, in which the former extracts resources from the latter, or, more abstractly, through the relation of capitalist society to nature. Moore (2011) criticizes such conceptualizations insofar as they rely on a Cartesian separation of two crises: the crisis of accumulation and the environmental crisis. Against this theorization, Moore proposes that "[i]t is the relation between social power and biophysical process (the oikeios) that has given rise to such crises" (11).

More than that, Moore argues that these crises do not occur as an accident of capitalist development, but as a necessary consequence of the extraction of value from humans and nonhumans. Thus, he proposes a world-ecological perspective in which "environmental history is every bit as much about factories as forests, stock exchanges, shopping centers, slums, and suburban sprawls as soil exhaustion and species extinction" (34).

His world-ecological perspective, however, does not imply a homogenization of nature and its situatedness, for otherwise it would rest on the false notion that "all of nature can be reduced [to] an interchangeable part" (17)—that is, the law of value applied to biological processes. Instead, Moore argues that "law of value as historical–material movement is inconceivable without the symbolic and scientific revolutions that 'discovered' the homogeneity of time and space in early modern Europe". This allows him to argue that there is continuity between processes fundamental to the emergence of capitalist private property—such as the enclosure of common lands that expelled peasants into proletarian life—and the

standardization of space and time, abstracted into meters and seconds and rendered convertible into value.

Both processes, which occurred around the same period, enabled the transformation of predominantly agrarian human labor into abstract labor to be sold on the capitalist market, and likewise transformed biomes and the beings that compose them into units convertible into value.

This double abstraction, as Moore points out, produces a dialectical contradiction that occurs, in the words of John Bellamy Foster (2000), "through the growth simultaneously of large-scale industry and large-scale agriculture under capitalism, with the former providing the latter with the means of the intensive exploitation of the soil" (156). Furthermore, according to Moore, this metabolic disjunction is sustained insofar as nature is, for capitalist agents, an object waiting to be possessed, from which its "gifts" are extracted—thus obtaining cheap raw materials, energy, and food. In the long run, however, these "gifts" are not so cheap, since the costs of maintaining productivity grow ever higher.

This cost is what Moore calls negative value, that is, "the emergence of historical natures that are increasingly hostile to capital accumulation, and which can be temporarily fixed (if at all) only through increasingly costly and toxic strategies" (2015, 104). In the context of his work, negative value is a specter haunting agricultural production since its entanglement with capitalism. Just as a factory must reinvest part of its capital in machinery to remain competitive, a plantation must invest its capital to make the land more productive—growing more crops per square meter and at a faster rate. This requires the use of various products, from fertilizers and pesticides to diesel-powered agricultural machinery and drones that collect crop data. As soil and climate degradation advance through the exploitation of the

"Green Revolution," the costs of maintaining productivity increase dramatically. Thus, the cheap nature from which value is extracted becomes expensive.

This thesis, however, is about data centres, not agriculture. How, then, are Moore's reflections relevant to this infrastructure? One possible connection arises from the vulnerability of infrastructures to climates for which they were not designed. A hydroelectric plant, for instance, is useless if the river feeding it is in a drought period. Data centres are built with climatic and infrastructural affordances in mind, prioritizing access to electricity. Thus, if hydroelectric power is no longer guaranteed—or no longer priced at a level that makes operations profitable—other, not necessarily renewable, energy sources will be employed. The very design of data centres takes environmental factors into account, from planning air circulation and heat expulsion to managing climatic events such as wind and rain. Climate change, therefore, can render architectural investments useless or put them at risk.

In this way, if data centres are climate-sensitive infrastructures, since they depend on it for value extraction, then the climate crisis presents itself as a negative value in a sense similar to Moore's formulation. The climate in data centres, however, is not only a site of value extraction or a risk demanding protection—it is the very locus of value production. In other words, it is through the labor that manufactures atmospheric and energetic conditions within these infrastructures that computation becomes possible and efficient. Thus, it is necessary to outline how energy and information are understood in the contemporary political economy.

The labor on air and electricity within a data centre serves the purpose of computation—whether for storing, transmitting, or processing information. As any average computer user knows, this equipment generates heat while also being sensitive to it. This heating can be a risk insofar as "[a]n alteration of the thermal contexts of media and communications, an

alteration of their invisible infrastructures, would corrupt media history, would capsize digital communications, and would disrupt the production of thermally dependent media objects at scale" (Starosielski 2021, 218). A simple yet fundamental conclusion is that controlling the temperature of a data centre prevents the deterioration of equipment—whether belonging to the centres themselves or to their clients. From the standpoint of a capitalist enterprise, however, this fact is not unique to data centres, as temperature imbalance could spoil processed meat in a meat plant or cause exhaustion in an automobile assembly worker.

What, then, is specific about a data centre's relation to energy and heat? The disruption described by Starosielski in the previous paragraph is not merely a qualitative difference from thermal risks in other infrastructures or productive activities. This is because the control over the environment produced by data centres becomes both the condition of operation and the commodity from which value is derived. The management of energy and heat flows—and their attributes—becomes vital. In this sense, a data centre is, or aspires to be, a closed thermodynamic system in which entropy must be reduced to zero.

Entropy is a concept from physics dealing with the relations among heat, energy, and work in closed systems—thermodynamics. Its origins coincide with the advent of the steam engine, as its purpose was to understand the transformations of energy and heat in the production of work. For academics and engineers such as Sadi Carnot and Rudolf Clausius, the concern was how energy, when transformed into work to power the engine, was partly wasted as heat.

This paradigm of physics became a model not only for understanding the natural world but also for organizing society. As Stengers and Didier Gille (1997) note, "[l]eaks, insulation, degradation—these three recurrent themes of the putting to work of heat in heat engines are identically the subjects of preoccupation that dominate another problematic of work, the putting to work of the populations of the industrial nineteenth century" (209). Thus,

preventing the degradation of energy was analogous to preventing the moral and physical degradation of the proletarian subject.

Between the nineteenth-century sociotechnical paradigm—according to which a system must be isolated from its environment to ensure maximum performance—and contemporary data centres that conduct thermal and energetic exchanges while remaining insulated from the external environment, there are authors whose contributions are relevant to this research, as they formulate a critique of capitalist political economy in thermodynamic terms.

As will be shown in the chapter on computing, the production of components and the deployment of computers for commercial use imply the creation of environments that seek to exclude any residual elements (that is, *waste* in the form of heat, in the case of computers in operation, or *waste* in the form of dust and other air impurities, in the case of processor manufacturing). This does not mean that these environments are thermodynamically closed systems. If the separation between the inside and the outside of an infrastructure seeks, in capitalist terms, "to separate what will become the working class from what will be nothing more than the dregs of society, the feared image of absolute dissipation" (Stengers and Gille 1997, 210), this means that the "remainder" of a production process—whether toxic waste or exhausted bodies—is discarded as *waste*, that is, entropic elements expelled into the environment surrounding the system.

"To put to work," therefore, can be understood as a set of techniques deployed to domesticate and make predictable the flows of energy, exchanges of heat, and performances of labor. From a capitalist perspective, entropy can be understood as a state of chaos or disorganization from which new forms of metastability can emerge. In this sense, George Caffentzis (2013) argues that entropy "enshrines capitalist pessimism, for it announces that the work-creating process degrades energy invested in any and every system, including the human" (50). This

degradation may take the form of a subject who resists the hegemony of a given context. To this end, he argues that "[p]risons are as integral to the production process as the gas that makes the engines go, as the caress that sends one off to the plant, (...) [f]or if there were no dumps of labor-power and constant capital, no way of eliminating entropic contamination, the system would stop" (55). The prison system, therefore, is not external or supplementary to the capitalist production system, but logically connected to spaces of value production—so that, from an entropic-capitalist perspective, one cannot exist without the other.

Thus, more than a paradigm of social organization, thermodynamics began to be used more broadly to address ecological processes within capitalism. The scope of a thermodynamic approach expands beyond a single system, such as an engine or a factory, to encompass the environment as a composite of historical-ecological relations. Authors such as Foster and Burkett, for instance, note that the degradation arising from "[c]apitalism's assault on the biochemical processes necessary to sustain the human-land system" can be understood as "a form of entropic matter-energy dissipation" (2016, 163). It is a destructive process that is co-constitutive of value production, allowing for a critical position on the relation between ecology and technology without assuming a Schumpeterian "creative destruction." Ali Kadri (2023), in turn, argues that "capitalism is both systemically highly entropic and induces high entropy. It dissipates the labour/energy of society and much of the overproduced waste is consumed or will be consumed at a time in the future" (495). Waste is not merely something to be buried somewhere far away, but an asset that can be transformed into a commodity again—such as the heat that data centres can sell to neighboring communities (Velkova 2016, 2019). Thus, an ecological understanding of value production at the intersection between infrastructure and environment implies paying attention not only to what is produced but also to what is destroyed.

Finally, entropy has another meaning in Information Theory, the field founded by Claude Shannon (1948). According to Shannon, entropy is the level of surprise that a communicated message can produce. Thus, flipping a coin has a lower level of entropy than rolling a six-sided die. In other words, the greater the uncertainty regarding the possible outcomes of a communicated event, the greater the entropy—and therefore, entropy equals information. To support this inference, we can take two hypothetical values: zero and infinity. Information with an entropic value of zero corresponds to having complete knowledge of a system, such that it causes no surprise in its receiver. Information with an entropic value of infinity (hypothetically, rolling a die with infinite faces), in turn, is undecidable, since it cannot be actualized.

A contemporary of Shannon, Norbert Wiener, in turn, established a relation in which information is the opposite of entropy, that is, negative entropy (Gleick 2011; Geoghegan 2023). In this sense, Wiener argued that as a society expands its "codes and relays" (indirect communication), it becomes more disordered, moving toward a state of high entropy in which organic social community is lost. Wiener's understanding encompasses society as a cybernetic assemblage, in which communication is a potentiality that manifests itself through different materialities. The profusion of these materialities multiplies the possibilities of information, leading to different social configurations and, therefore, to chaotic states.

Here it is important to explore the homology between the notion of entropy in Thermodynamics and in Information Theory. At first glance, one might think that the two fields attribute mutually inverse meanings to the concept—that is, in Information Theory, high entropy equals information *qua* potential for change of state, whereas in Thermodynamics, high entropy means the opposite: a state of disorder and indeterminacy. However, if we think of a thermodynamic system as a state within an arrangement of energy

and molecules, we can infer that Thermodynamics deals with the actualization of the system. In Information Theory, in turn, entropy also refers to the differentiation from one state to another—but as a potential for such change carried by information.

The relation between Wiener's and Shannon's ideas may appear antagonistic, as if one must be chosen at the expense of the other. However, Shannon himself downplayed this difference (Gleick 2011), and it can be understood as distinct perspectives on the same process. Shannon's notion of entropy can be understood as the potential for disturbance or change within a given medium. A book whose reading may alter the reader's understanding of the world, or a court whose verdict has multiple possible outcomes, would be examples of Shannonian entropy, insofar as they deal with the future possibility of transforming a system. Wiener, by contrast, holds an understanding of entropy closer to that of thermodynamics, that is, entropy as a state of undifferentiation—such as a book whose letters are randomly scrambled, or a court in which all participants are furiously fighting one another. Indeed, for Shannonian entropy to be actualized, entropy as understood by Wiener must be low.

Thus, entropy is the conceptual nexus that allows us to approach processes of value production both through the transformation of nature and humans into energy, and through the maintenance of a cybernetic system dependent on information. Energy, information, and computation are the foundational elements of this thesis's analysis—what remains is a mapping of studies on information and its infrastructures.

Drawing on Gilbert Simondon, Matteo Pasquinelli (2022) argues that industrial machines were the first to separate the traditional form of labor into information and energy. To understand this separation, one may take the Jacquard loom as an example: before its invention, the seamstress's hand, in manipulating the needle and guiding the thread, involved both the force that moved the hand (energy) and the direction taken by the needle

(information). With the loom, the design of the fabric was transferred to the machine, leaving the worker (formerly an artisan) to use their body as an energetic-regulatory appendage of the machine.

This separation—already anticipated by Marx in terms of the separation between worker and means of production—serves as a model to understand the gradual and continuous movement that led to the separation of human capacities, culminating in the quintessential form of late capitalism: mental labor. According to Pasquinelli, if energy was a metric equivalent to labor in the era when the engine was the dominant technological paradigm, information now "measures value in its capacity as a metric of labour and productivity" (18).

Information and its Infrastructures

If information is a metric, how is it assembled? In other words, what technological arrangements make information measurable? As infrastructures of enclosure, data centres are spaces of experimentation in controlling entropy—whether of human or nonhuman nature. In this sense, these spaces are a hybrid of discipline and control, resembling a prison.

In this regard, the work of Anne Kaun and Fredrik Stiernstedt on the relation between prison and media in Sweden (2023) is particularly relevant. They argue that the architecture and labor performed within the prison constitute "a medium in itself" (2), while media infrastructures inside and outside the prison make it a test bed for the development of carceral technologies. Thus, new forms of control and discipline over bodies are developed and refined not only for use on imprisoned individuals but also for other contexts.

Furthermore, by producing information about itself, the prison becomes a productive site beyond the sense proposed by Foucault in his analysis of the panopticon. It is no longer about producing productive subjects, but about producing informational models that refer to

behaviors, routines, and tendencies. Technological implementations, in turn, are accompanied by imaginaries that justify them and assign specific values to the things represented. In the authors' analysis, the introduction of technologies such as radio communication and CCTV carried hopes of "'automation,' 'humanization,' and 'effectiveness,' which often (...) had to be tamed or at least adjusted to the realities of everyday life in prison and the agency and resistance of the individuals living their lives there" (107).

Analogously, the implementation of surveillance and control technologies in data centres carries expectations that are constantly negotiated with the life and matter that escape the infrastructural grid superimposed upon them.

Tung-Hui Hu, in turn, draws attention to the use of bunkers to house data centres, since this involves "commanding a specific territory [that] rests on the supposed need to 'protect' the Internet from the Other" (2015, 92). More than a military analogy, he argues that this infrastructure that houses the cloud makes the internet into a sovereign territory. Sovereignty, in turn, seems anachronistic when applied to the digital technology that constitutes data centres. However, it is through this form of regulation of bodies—walls, barbed wire, and armed guards—that a primordial layer of power is put into practice. Thus, instead of conceiving a linear technological evolution that merely reflects modalities of power, Hu proposes "a different way of imagining not just the contemporary moment, but also how we approach history and futurity" (96).

Another relevant contribution from Hu is his consideration of the affective and phenomenological aspects invested in data centres. According to him, the architecture and functionality of the cloud (and its material embodiment, i.e., the data centre) operate analogously to melancholy, since "[j]ust as the melancholic creates a psychic architecture to hold and preserve its lost object, the data bunker closes off the 'outside' in order to secure

data from external threats" (108–9). His comment can apply both to users who depend on cloud storage to keep emails and personal documents, and to the motivations of my interlocutors for working and investing in this field. One can think, for example, about other psychic states that are not only present or stimulated among data centre workers and managers but also crystallized in the principles of technical standards, valuations of people and resources, and conceptions of the environment. Above all, Hu's provocation can be taken up to reflect on values, symbols, gestures, and sociability among the agents who compose the data centre milieu.

By paying attention to these elements, it becomes possible to outline the beliefs and values of individuals who work in data centres. Value, in turn, must be understood as inseparable both from its economic and quantitative sense and from the type of value that, at first, exists outside capitalist logic and shapes ethical and moral valuations. It is precisely due to this ambivalent sense of "value" that the final section of the literature review is dedicated to anthropology focused on the study of value.

Anthropology of Value

The understanding of economic processes and the production of value dates back to the origins of anthropology as a modern discipline. Examples include the work of Bronisław Malinowski and Franz Boas, who respectively studied the circulation of elaborate shell artifacts in the Trobriand Islands and the potlatch rituals of the North American Northwest Coast. In studying the Other in neocolonial contexts, these and other anthropologists sought to understand value not as an objective, calculable quantity circumscribed by the materialities of human relations and the things exchanged. Instead, processes of value composition and circulation—such as the shells involved in the Kula ring studied by Malinowski, or the destruction of blankets, copper plates, and other valuables in a potlatch observed by Boas—

must be understood as animated by spirit, constituted through obligations of reciprocity, and sustained by kinship relations and ancestral ties.

It is from this understanding that Marcel Mauss proceeds in *The Gift*. Drawing on the work of numerous anthropologists, Mauss outlines a logic of value circulation that cannot be reduced to the ethos of the modern *homo economicus*. Analyzing works such as those of Malinowski and Boas cited above, Mauss argues—often in a lamenting tone—that the modern society to which he belonged organizes its economy through a series of separations: between morality and law, debt and obligation, spirit and objects. According to Mauss, these separations produce a particular form of alienation in the modern subject, exacerbating individualistic and utilitarian tendencies and impoverishing human existence. In response, Mauss proposes that alternative forms of value—residual within society yet distinct from capitalist modernity—might be reworked in order to mitigate the existential misery he perceived.

One of the lessons Mauss attempts to convey in *The Gift* is that value is not necessarily an abstraction that separates individuals from their peers, their labor, and the meaning of their lives, as occurs with capitalist exchange value. It is important to note, however, that Mauss's proposal—by emphasizing premodern aspects of value still present within modern society—tends toward a certain reactionary orientation. Although not anti-capitalist, it seeks to mitigate capitalism's deleterious effects. In this sense, his position differs from a Marxist critique not only because of the evident ontological and disciplinary differences between the authors but also, and above all, because of their distinct temporal orientations. Whereas Karl Marx understood the overcoming of capitalism as the movement of society toward a new epoch—the true beginning of human history, in his formulation—Mauss did not advocate a return to an ancestral or archaic remnant. Instead, he envisioned the reactivation of certain

modes of relation between persons and objects that cannot be reduced to the economic dimension.

Anthropology thus makes it possible to explore modes of valuation that are not circumscribed by political economy as a component of modern thought. One might say that while Marx formulated a project of political emancipation within modernity, Mauss proposed the recovery and cultivation of modes of valuation that remain residually present after modernity has become hegemonic. It is precisely through the tension between Maussian and Marxian definitions of value that David Graeber argues in Toward an Anthropological Theory of Value that "the struggle to define value is fundamentally political," rather than a strictly technical or managerial endeavor. To advance this claim, Graeber proposes that value should no longer be understood as a static property of objects (a view he associates with Parmenides) but, drawing on the work of Nancy Munn, as something co-constitutive of action itself. This perspective leads him to propose an anthropological approach opposed to the fetishism of the object, which he attributes in part to Arjun Appadurai in The Social Life of Things (1986). According to Graeber, Appadurai's contribution is methodologically limited and rests on problematic political premises, particularly of a neoliberal character.

Against this current within anthropology, Graeber argues that ultimate freedom does not consist in the ability to accumulate value within an existing system, but in the collective freedom to decide what is ultimately worth creating and what makes life worth living. At first glance, his critique may appear directed solely at capitalism and the maintenance of an ideology grounded in individual freedom that paradoxically imprisons the subject. Yet his proposal seeks to move beyond a Marxist teleology of capitalism's overcoming. For Graeber, genuine emancipation lies in the possibility of collectively creating modalities of value, such

that society should “start thinking of what a more viable and hopefully less coercive regulating mechanism might actually be like” (Graeber 2001, 89).

Graeber’s contribution demonstrates how anthropology remains relevant for a critical approach to contemporary political and economic questions. By articulating Mauss and Marx as an analytical key for thinking about an anthropological theory of value, Graeber places human action at the center of his framework. The creative capacity of action becomes the basis for political and organizational lines of flight, a theme that runs throughout his work.

This research does not deny the merit of Graeber’s proposal. However, its appropriation cannot occur without mediation. The first concerns the context of the research itself and the human actors involved. Data centres and their managers do not stand in opposition to capitalism; rather, they occupy privileged positions within it. What these actors understand as value—as will be shown throughout the dissertation—serves as an analytical tool for capital accumulation and provides meaning to their professional lives. Moreover, the agency of these individuals is conditioned by the infrastructure that houses technological artifacts possessing agency in their own right: whether as autonomous proxies for accounting and surveillance processes or as symbolic artifacts that formalize discourses, procedures, and conduct. Above all, the emergence of new forms of value does not arise from a conscious necessity or latent desire among data centre professionals for alternative modes of life. Rather, it emerges from the blind spot generated by the recursive interaction between human actors, capitalist imperatives, and the technological systems that compose a data centre.

The quantitative notion of value, which generally refers to the condition of a commodity within the capitalist circuit, implies the act of counting. For Çalışkan and Callon (2009), such a process involves the performativity of agents engaged in valuation procedures. Performativity here is not understood in the sense popularized by Judith Butler (1993), but

rather through an approach that combines pragmatics with attention to things and materialities. With this, the authors seek an alternative to what they regard as a counterproductive duality—that of value regimes based on Marx and Mauss. While the former provides a critical grammar that exposes contradictions naturalized by ideology, the latter allows for the analysis of flows of objects occurring outside the capitalist circuit. However, Çalışkan and Callon question the static condition of value regimes, proposing *modes of valuation* as a conceptual construct for addressing the production and transformation of values. The pragmatics that set these modes in motion make it possible, according to the authors, "to understand flexibly why certain things have properties that facilitate their engagements in certain regimes of circulation valuation rather than in others" (389)—which, in the context of this research, refers to nature as an object awaiting possession, or information as a potential for value.

Above all, the proposal of Koray Çalışkan and Michel Callon will be appropriated here as a way to understand the performance of my informants, the majority of whom belong to the professional–managerial class, as they describe themselves and the companies that employ them as mechanisms of quantification and valuation. This performance is tied to artifacts of diverse kinds, ranging from ESG reports—which account for the environmental, social, and governance performance of these companies—to climate control and security systems. In this way, these resources operate, each in their own manner, as modes through which information, energy, and climatic variables are understood as resources, commodities, or waste.

Finally, it is precisely around the opposition between waste and value that the review of the next author's work will be situated. This refers to the influential work of Michael Thompson, Rubbish Theory. In this book, Thompson seeks to understand how the value of certain objects, such as antique furniture, oscillates not merely in quantitative terms but also through

the ways in which these objects are categorized and, consequently, valued. To address this, he proposes two categories related to value (understood as the degree of desirability for possession) and material life span. Durable objects are those whose durability is stable and whose value increases over time, such as a preserved Model T automobile, a Queen Anne walnut tallboy, or other high-end antiques. By contrast, transient objects are items whose durability and value decline over time.

For Thompson, in a simple two-category system an object could never move from transient to durable because their defining criteria are mutually contradictory: one must decrease in value while the other increases. He therefore proposes an intermediate category, rubbish. A transient object declines in value until it reaches zero and slides into a valueless and timeless limbo. It is as rubbish that an object, in a dormant stage (excluded from social time) remains at zero value while awaiting potential recovery into the category of the durable. According to Thompson, such recovery occurs through specific social pressures, whether aimed at elevating a particular cultural artifact to the status of historical heritage or at attributing aesthetic significance to it. These three categories, in turn, are mobilized through circuits of actors who deploy different strategies in order to produce or leverage the value of objects that interest them, thereby also obtaining prestige for themselves.

If a durable object is capable of maintaining value, as in the examples above, and a transient object may be discarded without financial loss or a sense of deprivation, where would a data centre stand within such a framework? This question is not central to the present research, since the objective is not to extract a conceptual scheme from one context and transplant it directly into another. Instead, it is the category of rubbish that will be abstracted in order to understand how the relationship between information and the environment shifts from noise and waste to signal and value.

The processes of measurement and economization performed by my interlocutors position elements such as heat, energy, and information within an indeterminate field of value, where they may be either valorized or devalued. From Thompson's perspective, it becomes possible to analyze one of my interlocutors' understandings of signal-value and noise-waste while exploring the possible values of information. As noise, information is rubbish, but of a residual kind, possessing a latent potential for use. Once possible ways of transforming it into signal are discovered, it becomes something with considerable potential value. Approaching information as a form of "digital rubbish" therefore makes it possible to understand its potential for valuation.

Chapter 2 - What is the Environment (According to Data Centres)?

Introduction

For an external observer, data centres can easily be taken as just another element of a mundane, naturalised landscape, much like power transmission towers in a hinterland. These buildings, like others designed to anticipate potential power outages, are equipped with diesel generators. In some cases, their sites also include their own substations, reducing dependence on energy distributors. They are fitted with climate control systems, typically composed of cooling units and air circulation piping. This configuration produces one of the peculiarities of data centres, already noted by Levenda (2019), in which "[t]hese infrastructures bring rare-earth minerals, electricity infrastructures, laboring bodies, fiber optic cables, knowledge, code, water, and fossil fuel together in a disturbing whole" (5). This consumption of human and non-human material and energy does not pass without consequence, but is felt in the spaces surrounding data centres—for example, in the shortages of water and energy that they can produce.

As a rule, productive and extractive activities have deleterious effects on the environment and its inhabitants. Alongside this, the arrival of data centres is accompanied by promises of economic development and employment that are often unfulfilled, or, as Burrell (2020) suggests, can be understood as "half-built assemblages," that is, "a different kind of material temporality, one of slow movement or even perceived non-movement, not a jittery one of moment-by-moment action and continual recalibration" (20). This temporality is at once fast

and disruptive in terms of tax incentives and the construction of data centres, and slow or static in improving the lives of those who live nearby. Thus, even though our way of life is closely tied to data centres, they are undesirable neighbours.

Unlike earlier periods, when companies were accountable only to their shareholders, there is now an external demand for information beyond their financial performance. Therefore, this chapter is the first step toward approaching data centres. Preliminary to the fieldwork proper, it explores a type of document issued by many companies in the sector: the ESG report. An acronym for Environment, Social, and Governance, this report provides an account of achievements and goals for each of these topics. Easily accessible, since they are published annually on company websites, these documents detail metrics on carbon emissions, recyclable waste management, social inclusion projects, compliance mechanisms, among other issues. These metrics do not stand alone; they are preceded by a discourse that links economic growth with workplace well-being and environmental responsibility. Thus, before presenting the decarbonization performance achieved in 2023, Scala's VP of Engineering states that "[s]ustainability offers an opportunity to forge a harmonious coexistence with nature, including driving innovative solutions to minimize energy consumption and carbon emissions" (Scala 2024, 19). Equinix, in turn, is more succinct and prefers to let the numbers speak for themselves. In the "Social" section, the company states that it is "a force for social good as we prioritize diversity, equity and inclusion, cultivate a people-centered culture, and invest to close the digital divide" (Equinix 2024, 6), before presenting charts on gender and racial distribution.

These discourses are not merely an effort by these companies' top executives to project credibility to stakeholders; they also introduce a way of measuring and pricing how the companies function. This holds for all three dimensions that make up the document, so that

the number of megawatts saved in the “Environment” section is as calculable as the number of people benefiting from Diversity, Equity, and Inclusion policies. More than that, these metrics aim to point to desired economic and moral effects: saving energy improves the company’s balance sheet and helps the planet; improving employees’ working conditions promotes their well-being and makes them more productive. In this way, the three dimensions of an ESG report frame certain aspects of the world through a reduction of the world to a resource, whether human or natural. This reduction, in turn, aims to make the world a better place, while it can also be read as data that simply represents reality.

As stated in the literature review, data, numbers, and other constructions relegated to the realm of the “technical” are generally taken as signs of politically neutral objectivity, when in fact they carry normative and descriptive aspects concerning how the world is and how it functions. Accepting uncritically the way these data are presented means submitting oneself to the logic proposed by those responsible for the report. It is from this premise that this chapter offers a critical reading of several ESG reports, in order to understand how the data they present is mobilized to produce a narrative that is hard to contest, shielded as it is by the fortress of numbers and data. Rather than simply observing the values these reports contain, the aim is to focus on the types of metrics used, in order to understand how these companies conceive of nature and people. Rather than questioning the reliability of the information these documents contain, the chapter seeks to understand how relations among different values are stitched together. These relations make up the framing of contemporary problems, such as the Anthropocene.

By questioning the meaning of these metrics, they cease to be descriptive grids of reality and can instead be taken as a self-referential discourse about how the people and their institutions —“socio-cognitive prostheses that facilitate efficient coordination” (Çalışkan and Callon

2009, 380)—that issue these statements see themselves. These statements describe not the world, but the way they see it and themselves, as well as the kinds of relations they establish with it.

Thus, the chapter begins by situating the period that frames both this research and ESG reports: the Anthropocene. Just as the time of the moderns (a straight line pointing toward the future) is only one among several possible temporalities, the Anthropocene as an unavoidable fact has its meaning politically disputed by different actors. Conceptualizing the beginning of the Anthropocene, its pace, and its possible end is inseparable from an understanding of its causes, so that different framings of human, sociotechnical, and political agency bring with them respective critiques and agendas for addressing the climate crisis. Defining the Anthropocene does not mean settling the debate once and for all, but rather situating this researcher's theoretical and political stance.

This reflection continues with two works that articulate politics, environment, and temporality. Focusing on oil and the refined violence derived from it, David Bond (2022) and Max Liboiron (2021) investigate how refineries and oil companies mobilize different kinds of artifacts to justify the pollution they produce to the individuals and communities affected by them. These artifacts—such as museums and billboards—catalog aspects of the ecology and culture of those who existed before the arrival of these companies, and mobilize ideas of the future that shape what is possible, impossible, and inevitable. Alongside a past and a future, an idea of environment is also produced, in such a way that these companies hold the prerogative to act upon it insofar as value is generated through the exploitation of place. Something similar occurs with ESG reports, with the difference that the extractive practice described in these documents appears less hostile than in the cases discussed by the two

authors. Instead of the exploitation of limited and toxic resources, data centres offer a virtuous growth of sustainable consumption and mitigation of greenhouse gas emissions.

Whether a data centre company is less harmful than an oil company, or whether an ESG report is cynically produced as an elaborate public-relations tool, are questions that do not concern this research. Instead, it asks what forms of environmental framing emerge when articulating concrete abstractions—or ontologically subjective ones, according to Hacking (1999)—such as CO_2, watts, and dollars. As companies trace a performance trajectory across these variables, they create narratives about their relation with the environment, while simultaneously defining a telos within the context of the climate crisis.

Anthropocene: Who, where, how?

The backdrop of this thesis is the Anthropocene. Proposed by Paul Crutzen (2002) in the article that gave the term its name, the Anthropocene as a geological epoch seeks to situate the consequences of human action on the scale of geological and climatic forces of planetary magnitude. The fact that opens his argument is that "[d]uring the past 3 centuries human population increased tenfold to 6000 million, growing by a factor of four during the past century alone" (1). The force of these numbers, combined with the "per capita exploitation of Earth's resources," has provoked diverse and systemic imbalances. Crutzen mentions the excess of synthetically fixed nitrogen in agriculture to make soil more productive, and the greenhouse gas emissions resulting from "increasing fossil fuel burning, agricultural activities, deforestation, and intensive animal husbandry, especially cattle holding" (3). To deal with this ongoing destruction, Crutzen proposes that "intensive research efforts and wise application of the knowledge thus acquired in the noösphere, now better known as knowledge or information society" (4), be implemented.

Crutzen's Anthropocene is, above all, a profound celebration of mankind and its capacity to exploit the planet's resources, which, according to the author, are "so generously provided by nature cost-free" (4). The cautionary tone of the article is intertwined with the celebration of humanity's ability to engineer a solution to the destruction underway, since "[h]umankind is bound to remain a noticeable geological force." Thus, the ongoing climate changes are nothing more than the realization of its technological potential, which can nevertheless be reversed for the very same instrumental reasons. Indeed, the author hopes that the Anthropocene—today more a threat than a dream—may in the future be referred to as shaped "by vastly improved technology and management, wise use of Earth's resources, control of human and domestic animal population, and overall careful manipulation and restoration of the natural environment." Thus, we observe a "humankind" endowed with agency capable of controlling, manipulating, and restoring on the one hand, and on the other, a generous nature that provides but is unfortunately being destroyed by a *homo sapiens* hesitant to apply its ingenuity toward preservation.

It is interesting to note an ambiguity in the temporal and agential demarcation of the beginning of the Anthropocene. Without pinpointing precisely which event or fact inaugurated this geological epoch, Crutzen proposes that at some moment in the second half of the eighteenth century the global effects of human activities began to be felt, suggesting the coincidence of this date with James Watt's invention—the steam engine. This delimitation, however, does not prevent Crutzen from referring to the agents in overly general terms such as "humankind," "mankind," or the taxonomic formality "*homo sapiens*." Precisely because it is apparent who is being obscured behind this terminology, the question is not to determine the "true culprit" for the planet's destruction, but rather to discuss the sociotechnical relations that mediate between humans and nature.

In The Great Acceleration (2014), J. R. McNeill and Peter Engelke deepen Paul Crutzen's work by exploring the energetic, demographic, climatic, and biological dimensions of the Anthropocene. The arguments of this work are relevant to this thesis both for the insight that gives the book its title—namely, the "twin engines" of acceleration, energy and population—and for its broader analytical framework. The "Great Acceleration" is defined by the authors as a moment in the post-1945 period in which "human actions become genuine driving forces behind crucial Earth systems" (207). Their argument can be organized along four axes: the periodization of the relationship between humans and nature and the temporality of the Anthropocene; the energetic and demographic components of acceleration; the intensification of anthropogenic pressure on the environment; and urbanization as a structuring dimension of this process.

As an environmental history focused on the post–Second World War period, McNeill and Engelke's work establishes a temporal thread linking humans to their energy sources, taking as its starting point the control of fire by hominins some 1.5 million years ago, moving through watermills and windmills, and arriving at modern forms of energy production. This trajectory, described in a linear and generalizing manner around a "humankind" inhabiting the Earth, is—up to premodern times—marked by a persistent effort to increase efficiency in energy acquisition. This effort is reflected in practices ranging from the use of fire to expand the range of digestible foods, to the organization of agriculture to maximize the transformation of solar energy into edible plants, as well as in the harnessing of energy for animal and mechanical labor. According to McNeill and Engelke, this dynamic underwent a shift with the burning of fossil fuels: whereas "humankind" had previously been constrained by energy scarcity arising from its embeddedness in environmental relations, with fossil fuels energy became abundant.

This abundance, combined with low extraction costs, enabled the acceleration of economic processes characteristic of modern societies, both in core capitalist countries and in peripheral ones. According to the authors, by 1870 this march of progress had already produced greenhouse gas emissions exceeding the global capacity of photosynthesis, such that "[o]ur species has probably used more energy since 1920 than in all of prior human history" (9). McNeill and Engelke then detail the disastrous consequences of this process, including catastrophic events involving nuclear power plants and oil pipelines, as well as everyday tragedies emerging from pollution associated with individual consumption of fossil fuels, as in the case of automobiles.

Alongside the emergence of energy as an abundant and inexpensive resource, the authors argue that—particularly in the postwar period—advances in public health enabled an unprecedented population increase. Improved hygiene and sanitation reduced mortality rates and extended life expectancy. With this growth, McNeill and Engelke contend, came increased pressure on natural resources such as water, both for consumption and agriculture. They note that "[t]he world's irrigated area also tripled (1945–2010), led by India, China, and Pakistan," and that "the main reason behind the tripling of water use was the tripling of population, because irrigation for food production took the lion's share" (52). Similar inferences are drawn in relation to other forms of resource exploitation, such as the destruction of biomes for monocultures and livestock. They also acknowledge cases in which environmental degradation is not directly tied to population growth, as with ozone layer depletion caused by chlorofluorocarbons (CFCs), which "were used chiefly as insulation, refrigerants, aerosol propellants, and solvents" (55).

The logical chain constructed by McNeill and Engelke suggests that "humankind" is, in a sense, a victim of its own success. After all, individuals seek the freedom to have as many

children as they wish, and few desire a short life. The means that enable this—products and services that heal, nourish, and protect the modern individual—are embedded in productive and logistical chains grounded in environmental exploitation. In this sense, it is as though the vitality of non-human nature were extracted in a vampiric manner to be absorbed by its antagonist. While the population growth resulting from these processes already posed challenges by the late nineteenth century, the Great Acceleration of the mid-twentieth century expanded this growth into the Global South, particularly former British colonies such as India and China. McNeill and Engelke pay special attention to these two countries, both in terms of their rapid population growth and the draconian policies implemented to curb it. Between the environmentally catastrophic consequences of extended life expectancy in developing countries and non-liberal measures such as China's one-child policy, the authors appear to encounter a conundrum—one that might be avoided by considering the underlying driver of this acceleration, namely capital.

If, for the period from early humanity to premodernity, it is possible to construct and deconstruct explanations that rely on certain ideas of human nature, the same endeavor is less straightforward when dealing with a past that continues to shape the present. It is undeniable, for example, that cheap energy has been foundational to liberal democracies, socialist governments, and state capitalist regimes since it began to be unearthed and burned. If acceleration is intrinsic to modernity, then the critique might seem to apply less to a specific mode of production than to the modern subject and the epistemology that posits a separation between humanity and nature. However, it is not possible to account for the technoscientific revolutions mediating this relationship without considering the emergence of capital as both an abstraction and a set of concrete social relations that have driven the expansion of extraction, colonization, and manufacturing. In this sense, primitive accumulation—even when incorporated into non-capitalist ideological regimes—functions as a practice of

expropriating matter and non-human processes into a pool of resources. By analyzing both poles of the Cold War under the rubric of environmental degradation without situating modernity as intrinsically tied to capitalism, the authors risk producing a comparison of state forms and economic policies that overlooks their convergent environmental practices, thereby establishing a false symmetry in critique.

Above all, *The Great Acceleration* examines environmental problems from an angle that, as will be shown later, data centre companies not only present themselves as solving, but upon which their profitability depends. This development is not surprising, since, as argued above, McNeill and Engelke reduce the diversity of human development to a monolithic notion of "humankind," grounded in an understanding of technological progress centered on efficiency and the expanding extraction of natural resources. By failing to adequately emphasize the logic of capital accumulation that drives and accelerates this process, what remains is, on one hand, a fatalistic understanding of modernity, and on the other, a form of militant voluntarism.

If the Anthropocene emerged in the late eighteenth century, and if James Watt's steam engine is an indication of this emergence, then one can state that the Industrial Revolution—and therefore the modern subject—are respectively the central event and agent of this process. Thus, even if only timidly and vaguely, Crutzen defines a temporality and an initial cause. It is from this point that Heather Davis and Zoe Todd contest such a diagnosis. In "On the Importance of a Date, or Decolonizing the Anthropocene" (2017), the authors propose that the Anthropocene did not begin with the Industrial Revolution, but rather with the colonization of the American continent. To do so, Davis and Todd take as reference the "Orbis spike," a term coined by geographers Lewis and Maslin (2015) that points to the drop in atmospheric carbon dioxide between the early fifteenth century and the mid-eighteenth

century. This drop occurred because forest vegetation reclaimed the territory of peoples exterminated by European invaders, increasing carbon absorption and therefore decreasing its concentration in the atmosphere.

The “Orbis spike,” then, serves as the argumentative axis for presenting Indigenous genocide as a geological mark, given the planetary effect this event had on the climate. This allows the authors to treat Crutzen’s marker not as an initial point, but as a continuation of practices of dispossession and primitive accumulation that secured European presence in the Americas and paved the way for industrial development in the Old World. As scholars with Indigenous ancestry or biographical ties, the authors appropriate the Anthropocene by making explicit that its colonial manifestation is embedded in the suppression of Amerindian cosmologies and in the separation between thought and land. The notion of the noosphere—recurrently used to refer to the semiotic, informational, or cybernetic layer, depending on the author—is, for Davis and Todd, the epistemic manifestation of this violence. Thus, the Anthropocene as a modern project manifests itself through the destruction of a heterogeneous meshwork followed by its reconstruction in Cartesian, modular, and homogeneous terms (terraforming).

Davis and Todd’s critique is important because it shifts the focus away from a technology—whether the steam engine or the entire infrastructure that was built around it—and back to the political relations that employ technologies for particular ends. However, if Crutzen is vague and generic in how he points to the agents of the phenomenon, Davis and Todd restrict agency too much, and this has consequences both for formulating a politics of the Anthropocene and for a more precise conceptualization of this epoch, the agency that brought it about, and those affected by it. The first point to consider is precisely what serves as the premise for their article, that is, the chosen date. The authors choose the year 1610, the date of the “Orbis spike,” because, according to them, linking Indigenous genocide to climate

change “allows us to understand the current state of ecological crisis as inherently invested in a specific ideology” (764). The authorial subject “we” that made this decision is, therefore, the peoples who lived on the “new” continent before the arrival of the first Portuguese caravels.

The colonization of the American continent, however, is one process among others that shaped the world we live in. Just as decisive as the occupation of the Americas were the enclosures in England, the formation of boroughs in Europe, and the triangular trade between Africa (slaves), the Americas (sugar and cotton), and Europe (manufactures). These and other processes produced their own victims, such as English commoners and enslaved people. Both, however, cannot be reduced to settler colonialism, whether because of distinct (albeit connected) contexts, or because they engender other modes of power and other relations with nature. In this sense, pointing to a date implies pointing to an agent, and only one, running the risk of establishing a reductionist causality and a Manichaean politics around complex processes.

Agreeing that a position is necessary regarding the constitutive events and agencies responsible for the Anthropocene, the next authors offer arguments that, without denying Davis and Todd’s central propositions, address the issues raised above. The first is a recurring interlocutor in this thesis, Jason Moore. Indeed, in the first part of two articles titled “Capitalocene” (2017, 2018), he questions who the “we” is in this humanity responsible for planetary destruction. To answer this question, the author, as the title suggests, argues that capitalist civilization is the locus of environmental destruction. With this, Moore maintains that social dynamics such as population growth are subsumed under the politics of capital, such that it interpenetrates the technology in use (2017, 598). Above all, Moore argues that capitalism is premised on the separation between Humanity and Nature (with a capital H and

N), since these are concepts that are historically constructed and possess operative force in reproducing the world, justifying violence and domination, and that this separation is at once an expression and an instrument of alienation in its Marxist sense[5].

Thus, more than denouncing the Capitalocene as a practice of violence, exploitation, and injustice, Moore traces the technical and intellectual means through which this occurs and becomes a constitutive condition of contemporary societies. An example of this is "the process of simplification and quantification that reached an early peak in the Low Countries and the Dutch Republic after 1600," where new forms of surveying, water control, and radical rationalization of work-time and money emerged, such as the Amsterdam Bourse (2018, 259). It is this kind of rationalization that made it possible to standardize commodity prices worldwide and organize investment and labor exploitation in places both within and beyond Europe. Above all, the advent of financial instruments such as those mentioned by Moore are symptoms of the emergence of a calculating subject who places the price of all things under the same regime of counting—and this is no different today, as the next part of the chapter will show with ESG reports. Thus, the production of this kind of labor, nature, and accumulation is not confined to the American continent, nor to the exploitation carried out by settlers.

In mentioning the Cartesian dualism that separates Humanity and Nature, Moore approaches the stance of Davis and Todd, since this division is one of the foundations of the modern epistemology the authors denounce. However, Moore diverges from them in proposing the idea of an "Unholy Trinity of Capitalist World-Praxis," composed of abstract social labor (the general time–energy cost for a society to carry out an activity or produce a commodity), abstract social nature (the transformation of environments initially devoid of modern subjects

5 "Peão," literally "pawn," refers to manual laborers—typically construction or industrial workers—with little or no technical training. Due to its reputation, SENAI is known for producing "luxury peões".

into resources), and primitive accumulation. If abstract social labor is a way of understanding capitalist exploitation already outlined by Marx (1977), Moore argues that a critique of political economy oriented toward ecology must grasp the specificity of extraction in non-urban and non-industrial contexts. Thus, he proposes that abstract social nature is produced "through a repertoire of strategies comprising law, property and surveying, mapping," and, following Foucault (2003), disciplinary modes of accounting, surveillance, and hierarchy, such that "the defining characteristics of abstract social nature are control and appropriation" (Moore 2018, 253).

Thus, according to Moore, abstract social labor is tied to time, since the Marxist law of value rests on the labor time that is not paid to the worker. Abstract social nature, in turn, would be associated with the spatial dimension of exploitation, not strictly of human labor, but above all of cheap nature, that is, the raw materials that nature "offers for free," in Crutzen's words. This systematization, however, seems to relapse into the very dualism Moore criticizes, not in terms of nature–culture, but of space–time. More than a contradiction, this thesis argues that such a distinction does not hold, since the site from which abstract social labor is set in motion has a spatiality—whether in factories, in the city, or in the infrastructures that connect city and countryside, colony and metropolis, the global North and the rest of the world. Conversely—and this point is central to addressing data centres in their specificity—a temporality is produced within abstract social nature, whether by unearthing minerals that took millions of years to form, by interrupting the flow of a river to store water, or by using chemicals to accelerate the growth of crops and livestock.

There are other epochal designations used to approach the contemporary environmental crisis. Donna Haraway, for example, views the Anthropocene as a boundary event rather than a geological epoch, marking severe discontinuities, where "what comes after will not be like

what came before" (2015, 160). She proposes the term "Chthulucene" not as a negative or cautionary label for an ongoing temporality, but rather to emphasize the potential "to join forces to reconstitute refuges, to make possible partial and robust biological-cultural-political-technological recuperation and recomposition, which must include mourning irreversible losses." This irreversibility, as will be shown over the course of the thesis, is ignored or denied, however illusorily, by the people with whom I established contact.

One can say that the Anthropocene is a cumulative and ever-accelerating effect of the capitalist exploitation of human and non-human nature. This understanding allows us to approach the phenomenon in its systemic character—that is, in causal rather than fatalistic terms. At the same time, such an understanding makes it possible to establish different degrees of responsibility among individuals and the systems of which they are part. For the purposes of this dissertation, this does not imply identifying victims and perpetrators, but rather understanding how practices of exploitation and destruction are carried out and justified. With this in mind, the following authors develop these questions from the situated contexts in which they conduct their research and activism.

Temporality of the Environment

Imagine institutions that control infrastructures vital to the functioning of society. In addition, they demonstrate deep concern for the environment, meeting self-imposed targets for clean energy consumption and implementing recycling programs. As if that were not enough, these institutions also care about people—both those who work for them and those living in the surrounding communities—through education and mental health programs, as well as by creating jobs. One might think that such power and care for the environment and for the people who inhabit it describe a state agency or a well-funded NGO. These are, however,

common self-descriptions offered by data centre companies, particularly in their Environment, Social, and Governance (ESG) reports.

Such reports are not exclusive to data centre companies. Their emergence can be understood as a symptom both of the failure of the state as a guarantor of a commons necessary for the reproduction of life, and of a social demand placed upon large corporations regarding their responsibilities toward communities and ecosystems. Nestlé, for example—while selling products with high sugar content to children in the Global South—produces a sustainability report composed of indicators such as "opportunities for youth" and "foundations for ethical business," measured by the company itself. In this way, such reports render the company that publishes them accountable to a proactive agenda aimed at goals not directly tied to its *sine qua non* condition, namely, generating profit.

The first impression these reports may give is that they are public relations tools disguised as proactive agendas for compensatory policies. Before demands arise and unexpected harms from productive activities become visible—and worse, before they are articulated by individuals and groups outside the company's domain—risks and externalities are already anticipated, giving companies an advantage in proposing reparations on their own terms. In his work on tar sand oil extraction in Alberta, David Bond (2022) demonstrates that corporate interest in the discursive production of a "timeless indigenous environment" is a "way for companies not only to acknowledge the risks of their tar sand operations but also to delimit their responsibility to them" (108), such that the very idea of an environment is produced through investment in the culture and history that precede corporate occupation. If there is a timeless environment—devoid of history—then the land opened up for exploitation is merely a "loan" in the name of prosperity, with the value obtained from oil extraction enabling reverse terraforming that will restore life as it once was, perhaps even better.

How is this imagery of the environment produced? Bond describes the work of oil companies as "epistemological labor of purification and silencing that critical scholars and Native leaders have long rejected as colonial through and through" (93). Such epistemological work may be performed by the usual suspects—accountants and engineers who reduce the world's complexity to countable numbers and vectors. It may also mobilize a whole body of experts trained in the social sciences, such as ethnographers brought in to listen to affected communities, map their ways of life, understand their relations, and inventory their material culture. This work materializes not only in environmental engineering projects designed to reconstruct the damaged environment, but also in modes of establishing and directing dialogue with affected communities to co-opt potential dissenting actors. This effort also materializes in architectures and languages that organize symbols, discourses, and images. In his fieldwork near extraction sites, Bond notes: "The present destruction is displaced by the promise of what is to come. Active mines visible from the highway have billboards along them: 'Reclamation in Process.'" (110). In this sense, according to Bond, there is a temporal effect in this imagery: Indigenous lands become a consumed past of progress and a future-to-come, provided that oil remains profitable. Between past and future, the present becomes the temporal locus where politics is hypostatized so that instrumental rationality may operate without friction.

The tar sands museum in Alberta, from which Bond observes the framing of nature and culture, is emblematic: there, he notes an aerial photograph of oil extraction operations with the following caption beneath it: "'Who is responsible for protecting the environment? (A) The Government; (B) Oil Sands Companies; (C) Everyone.' The correct answer, the fine print explains, is everyone" (2022, 108). Both the museum and advertising billboards are artifacts that help companies justify their extractive activities—whether by distributing responsibility or by promising a future better than the times that preceded them. They are as

essential as the tractors, pipelines, and engines that unearth the oil, for it is through the "why" of their operation that negotiation, co-optation, and silencing of different agents (or *stakeholders*, in corporate language) becomes possible.

Temporality is also a central aspect in Max Liboiron's analysis (2021) of the relations between moderns (in the context of their writing, marked by Indigenous resistance in Canada, understood as *settlers*) and the environment they occupy. In close dialogue with Davis and Todd, Liboiron develops their critique from the contrast between Indigenous cosmology and modern epistemology. Thus,

> *"The temporality of Resource is anticipatory—it makes and even aims to guarantee colonial futures. Crucial to this temporality is the belief that this future can be chosen and that the present can be directed toward it via management practices. As such, Resources eclipse other possible relations with Land both now and in the future"* (65).

Although straightforward, Liboiron's argument is dense and deserves careful examination. The capitalization of "Resource" and "Land" is intentional: the author seeks to translate modes of existence that exceed epistemology and its primary mode of expression, writing. Recognizing that translation never finds an exact equivalent between languages/cosmologies, Liboiron describes *Land* as a verb—a thing/entity in which the soul of its beings is intertwined with it, such that each relation to it is situated and therefore unique. Its counterpart, *land*, is the result of the settler (modern) intervention that conceptually and physically separates the terms of this relation. Both are violent, for they impose categories that separate fundamentally relational beings into discrete bodies, turning them into subjects and objects, each with its own technologies of domination. Through this separation, *land* as a Cartesian extension of space comes to house *nature*, an object awaiting possession.

With the conceptual and technological production of *land*, *Land*, as lived by Indigenous peoples and described by Liboiron, ceases to be a continuum between humans and non-humans and becomes a space with linear, intransitive instrumental ends. A forest exists to be consumed through timber extraction or to offer its soil nutrients to agriculture, while a river becomes a resource for fishing or for waste disposal. Liboiron focuses on this latter example, showing that—as a pollution sink—the river (any river, abstracted into the functions assigned by modern-settler epistemology) becomes a *Resource* whose pollution threshold becomes an administrable variable. The management of this and other variables, in turn, is not a benevolent gesture fueled by settler guilt, but an extension of this violence. According to Liboiron, "[m]anaging the line between contamination and pollution, now differentiated as fundamentally different states, became a defining feature of environmental governance, and remains so today" (57). This governance determines the statistical risk of harm that a given amount of pollution may cause to a community and which beings will have their coexistence foreclosed.

Thus, the environmental management of pollution institutes a temporality that suspends the future of *Land* insofar as it is appropriated as an object of exploitation—whether for an economy oriented toward value production or for its counterpart, waste. Conversely, the linear future—composed of controllable variables—becomes as inescapable as the dependence moderns have on their infrastructures. This produces a false idea that the future is performed on the terms of the technoscientific apparatuses that mediate the agency moderns exert over the world they take as given. This performance, in turn, operates through the signs that represent aspects of these systems' functioning: the amount of carbon dioxide emitted, the watts generated per cubic meter of water, or the gallons of oil extracted. *Future equals progress* and, as a manager stated in a talk I attended on energy for data centres, progress must occur in exponential growth.

The pollution to which Liboiron directs their attention is plastic, which leads them to think about temporality in intergenerational terms, given the persistence of this residue. Bond (2022) also articulates politics and temporality when discussing the environmental and health effects of PFOA, a carcinogenic toxin whose molecule is virtually eternal. In both cases, the hydrocarbon is simultaneously an agent and a symbol of environmental injustice, often accompanied by racism and colonialism. Such are the deleterious effects of burning and refining hydrocarbons that the IPCC (Intergovernmental Panel on Climate Change) has, since the 1990s, published reports on the risks of climate irreversibility if carbon emissions are not mitigated. In other words, even if one were to ignore the relation between colonial and capitalist exploitation and environmental degradation, a supposedly "sanitized" political discourse still highlights the threat posed by a hydrocarbon-based economy.

The setting of my research, however, presents itself differently. Unlike the stigma attached to fossil fuels, data centres evoke infrastructures and imaginaries that claim to overcome this logic. Instead of the linear and finite consumption of oil and coal, renewable electricity is presented as a cyclical and potentially unlimited alternative for a so-called sustainable future.

Taken at face value, such a promise represents a technosolutionism that in a single stroke saves the world from the impending doom brought by dependence on fossil fuels and stimulates economic development—this time by merely transforming into useful energy for humans the forces that already exist in nature, such as river water, wind, and solar radiation. A cycle, rather than a line of development, would dictate the tempo of business and progress —this time *with* nature, rather than against it. Even if this narrative were as clean as it claims to be (it is not), one might still ask what kinds of relations these humans—now consumers of electricity produced through the labor of rivers, air, and sun—are establishing with nature. Relations that, before altering nature, first produce it. This production occurs both

conceptually, in the abstractions that compose epistemologies, and in the sociotechnical assemblages that transform nature into utility and value. These tools enable moderns to see nature in particular ways, measuring it, mapping it, classifying what is valuable and what is disposable.

Thus, just as museums and billboards are artifacts that present companies to the public in a positive light, data centre companies issue an artifact that fulfills a similar function—that is, to frame nature on their terms while casting themselves as agents that align value production with social and ecological progress. The data present in these documents compose ostensibly neutral discourses, for they are "merely" numbers reflecting the results of these companies' efforts. What kind of reality do the values contained in such a document perform? How does a particular arrangement of data produce a narrative? It is by exploring the constitutive elements of this specific genre of report—the Environment, Social, and Governance (ESG) report—that the remainder of the chapter will trace how data centres define the environment and how they frame the challenges and objectives of the companies that publish them.

Performing Utopias

When I began gathering information online about data centres, the aspect that initially caught my attention was the *eco-friendly* aesthetic that many companies employ. With leaf-shaped logos, green website design, and photos of facilities featuring architecture adorned with plants and benefiting from natural sunlight, there is a notable effort to establish an imagery of symbiosis between digital technology and a particular idea of nature. This effort is expressed not only in semiotic terms, but also through partnerships with recycling NGOs, internal policies for resource reduction, and initiatives aimed at tree planting. These actions have

symbolic value in themselves, serving as a way for corporations to demonstrate something like a moral conscience that legitimizes them as capitalist enterprises.

However, this type of action is not limited to gestures of marginal impact. Rather than merely expressing a counterbalance to the common externalities produced by large infrastructures and businesses, these actions are symptomatic of the ways data centre companies organize themselves, understand their surroundings, and establish relations with the world. These relations, in turn, are circumscribed by an economic logic—whether through tree-planting that can be counted as carbon credits, or through workforce development aimed at producing labor to be exploited.

Above all, these initiatives are not isolated gestures or *loose projects* arbitrarily implemented by some conscious decision maker, but part of these companies' mode of operation. The object that will be the focus of the rest of this chapter—the ESG (Environment, Social, Governance) report—makes this clear. These reports are analogous to balance sheets, presenting a company's performance across the indicators associated with the three components of the acronym. Beyond their most obvious effect—framing problems in terms companies can handle while leaving out issues and processes that might tarnish their image—what matters here is understanding the worldview these documents convey. As I will argue, such a worldview produces a temporality of progress both through the quantification and economization of aspects initially irreducible to numbers or economics, and through the inclusion of certain subjects within the company. The expectation, then, is that the approach to the research corpus—that is, the people and technologies that constitute data centres—will be preliminarily shaped by this macro-human agent: data centre companies.

As expected, auditing marginal metrics—sometimes even detrimental to value production—is a luxury not available to all companies. Thus, it is generally larger firms that devote resources

to measuring carbon emissions, calculating indicators of social inclusion, and assessing democratic governance. Saying that ESG reports are a luxury, however, misleadingly suggests they are merely public-relations devices, superficial attempts to humanize companies that hold dominant positions in their markets. Although such reports may indeed serve this function, the critique that concerns me here is not a moral one about the cynicism of politically correct discourse grounded in predatory capitalist practices, but an analytical one regarding their pragmatic and symbolic potentials. What is articulated in these reports (and in the discourse of the interlocutors I met during fieldwork) is not exactly a discourse that masks some underlying truth, but a vector of agency: one that produces a worldview and a *telos*, and that shapes the practice of specific human and interspecies relations within the context of data centres.

Moreover, ESG reports are a peculiar type of document. Although they are not archives in the strong sense of the term—artifacts containing knowledge, discourses, and data about a given period—their formatting implies a particular way of understanding how data centres are situated in the world. More importantly, written and published annually by the companies themselves, these documents address milestones in sustainability, certifications obtained, implemented programs, and other achievements. Thus, one should expect them to emphasize the goals reached over the course of the year. By adopting a perspective in which there are no failures or shortcomings, these reports provoke an impression of virtuous growth, in which sustainability means increasing consumption of clean energy, complete control over waste, and a surplus of value that overflows toward disadvantaged groups and the environment. This synthesis is performed through an articulation of narrative, data, and iconography that portrays the role of data centre companies in the world. What role is this? How is this role grounded? What kind of imaginary do they seek to construct?

Understanding the performative aspect of the reproduction of reality requires an analysis of the notion of performance. The author who inaugurated what came to be known as the "performative turn," J. L. Austin, was interested in utterance as an act that affects a particular state of reality. He proposed two modalities of utterances: one that merely states or describes reality, and another that effectively acts upon it—the illocutionary act. Examples of the latter include moments in church and in court, when a priest declares a couple married or when a judge pronounces a defendant's sentence. In both cases, the voice of the enunciator produces concrete effects in the world, affecting it.

The existence of performative utterances allows us to consider language beyond its representational function. Language is not something outside the world merely describing the state of things; it is in the world, in reciprocal agency with it. With this in mind, Judith Butler expands Austin's proposal by articulating Foucauldian theoretical references with the illocutionary function of language. For Butler, subjectivity and act form a process of mutual reiteration, "a materialization that stabilizes over time to produce the effect of boundary, fixity, and surface" (Butler 1993, 9). Thus, for example, a man is not an individual born with certain biological characteristics deemed masculine, but someone who produces his body through the articulation of matter (hormones, clothing, tools) and culture (gesture, uses of the body, sociability). In arguing that gender is a dimension of the process between subjectivity and act, Butler appropriates Austinian performativity for questions of gender and embodiment, expanding linguistic pragmatics beyond speech. Above all, Butler proposes a notion of performativity centered on the production of a corporeal self, not merely a representation of roles—as in Goffman (1969)—thus adding a micropolitical dimension to the materiality and performativity that constitute a subject.

The performativities of Butler (1993) and Austin (1975) are, respectively, analytical frameworks for understanding the production of bodies and contexts. More than this, they show that reality is subject to performativity—whether in illocutionary acts or in the body as a locus of agency. Michel Callon (2006) is critical of this performative maximalism because, according to him, it privileges an idea of culture at the expense of the sociotechnical dimension inherent to human life. Influenced by Latour, Callon argues that nonhuman materiality and its assemblages also matter, and thus performativity must account for the sociotechnical devices that compose a given milieu. Performativity, therefore, does not emanate solely from the human, but is distributed and negotiated among individuals and the artifacts they manipulate.

Returning to ESG reports, they enunciate aspects that produce the conditions of agency over their reality. The enunciation they perform, however, does not share the pragmatism proposed by Butler and Austin, since they are documents concerned with auditing aspects not always central to the economic scope that guides a firm. Analyzing them as agents that perform a reality thus implies focusing on how discourse is articulated in composing these companies' worlds. The first aspect that grants authority and truth-value to these reports is the authorship of individuals at the top of the hierarchy—CEOs, CTOs, and other leaders. Responsibility for their publication is not dissolved in the anonymous impersonality of the firm; it is centered on leadership. These reports, therefore, as they conceal potential frictions and failures in their programs and goals, distill metrics and confer meaning upon them. Because they are published on company websites, the initial impression is that they are accounts rendered to society. Are they merely a public-relations device?

More than a device, ESG reports are artifacts in which facts are produced and stabilized through technoscientific material agency (Latour and Woolgar 1986). This does not mean

that results and numbers are arbitrarily invented, but that they arise from negotiations between human plans, environmental conditions, and technological limits. It is in the relations among these elements that numbers—whether tons of carbon, gigawatts, or dollars—are calculated and recorded. While the sociotechnical assemblages will be analyzed in the following chapters, what matters here is the way semiotic, discursive, and quantitative elements perform a synthesis of nature, society, and technology for the sake of value generation. Consider, for example:

Appendix 1[6]: The CEO's letter in Scala's 2023 report addresses customers, employees, society, and investors. To each of these groups, there is a commitment, respectively: "to delivering the most sustainable, efficient, secure, future-proof, and cost-effective infrastructure in the market (...); to fostering a healthy and safe working environment and to heavily investing in professional education (...); to creating economic value in a manner that addresses societal needs and challenges (...); to delivering exceptional value, ensuring a solid and responsible financial return." (5)

Appendix 2[7]: Ascenty (2024), driven by the "production of data around the world and, consequently, the demand for more storage space," claims—according to its CEO—to take seriously its "role in the evolution of the market," working "toward sustainable, fair, and ethical development" (2).

6 An autobiographical note: One day, during my primary school years, the school invited a man to speak about energy and the environment. His presentation began with photovoltaic panels, explaining how they worked and their benefits. Then he turned to their problems—and there were many. According to the presenter, the pollution from discarded panels, especially toxic and non-recyclable minerals, outweighed the benefits of using this energy. He then compared the environmental costs with the energetic advantages of petroleum, concluding that the use of hydrocarbons was more advantageous. Even to a small and naïve Gustavo, the presentation sounded rather strange.

7 Roughly speaking, hydropower plants with dammed rivers have greater capacity to store energy, at the cost of environmental impacts from flooding. Run-of-river plants, in contrast, have reduced environmental impact because they capture energy from the river's flow, foregoing energy storage.

Appendix 3[8]: The leadership trio at Equinix (2024), as a sign of their commitment "to be the platform where the world comes together, enabling the innovations that enrich our work, life and planet," mentions the signing of 21 Power Purchase Agreements for clean energy, expecting "to generate more than 3,000,000 MWh of clean energy, equivalent to the amount of energy consumed by 600,000 European households" (3).

Somewhat personalist in tone, the "CEO Letter," which opens most ESG reports, articulates economic growth with a self-imposed obligation toward topics that—given the raison d'être of capitalist enterprise—might otherwise be less important than a positive quarterly balance sheet. With the exception of Scala, which explicitly addresses employees, society, investors, and customers, these companies—represented by their leadership—present to an undefined audience a correlation between value production and care for people and the planet. As these utterances produce expectations and a particular image of what these companies are capable of doing, they also raise questions with the potential to reveal sociotechnical logics encapsulated in terms such as "data," "energy," or "future": What does it mean for something to be future-proof? What kind of future is this? How and why is data production increasing worldwide? How is data produced? What does an amount of energy equivalent to that consumed by 600,000 European households actually signify?

Making the Environment

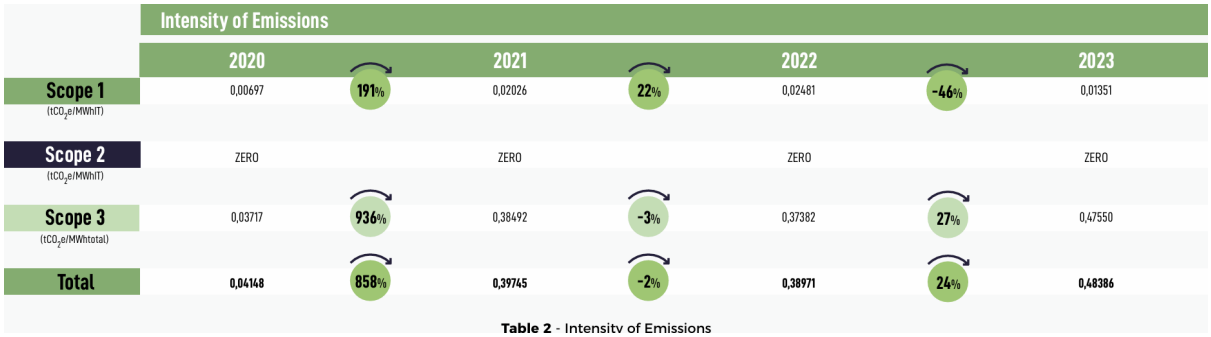
The pages that follow the executives' greetings do not answer these questions, but they do intensify them. The first topic generally addressed in the reports is the first letter of the

8 One could undertake a discussion about the discourse of truth surrounding violence in both the documents collected in *Shamanism, Colonialism, and the Wild Man – A Study in Terror* and the "Figueiredo Report." This is not to question the reality of the crimes committed by Brazilian government agents nor to assert that the accounts from Spanish America transparently record historical events. Rather, it is to observe that, as textual forms, both Taussig's materials and the documents recovered by Brazil's National Truth Commission reproduce the affective force of terror inherent to Western forms of sovereignty grounded in state, colonial, ecclesiastical, and capitalist power.

acronym, *Environment*. The common emphasis in this section lies in articulating data that present economic growth and net-zero environmental impact as co-constitutive processes. The success of this relation is of great importance to these companies, as it places them—at least at the level of imagination—in an environmentally superior position to sectors known for their pollution, such as extractive and manufacturing industries. Thus, Equinix, for example, increased its electricity consumption from 7,750 GW in 2022 to 8,170 in 2023, while total carbon emissions were reduced by 24% compared to the 2019 baseline year. Ascenty, in turn, has been carbon-neutral since 2020 (through the purchase of iREC certificates and financing projects that generate carbon credits), and it also increased its consumption of 100% renewable energy by 19.4% in 2023.

The growth in energy consumption has a double effect within the discourse of these companies: as they grow economically and demand more energy, they mitigate environmental impact in comparison to other productive activities. The systematization of this virtuous cycle appears with slight variations across the reports. Scala, for example, organizes carbon emissions into three scopes: the first, direct emissions from company-owned or controlled operations; the second, indirect emissions from the generation of electricity, steam, heat, or cooling purchased by the company; and the third, emissions from the entire value chain, such as business travel, emissions beyond operational control, and the acquisition of raw materials. The chart presenting these data (Figure 8) shows the intensity of Scope 1 emissions (internal to the data centres) in the years 2020, 2021, 2022, and 2023, revealing a steep increase in greenhouse gas emissions between 2020 and 2021—the period of building construction and the start of operations—followed by a decrease of nearly half between 2022 and 2023. This success, according to the company, “was possible thanks to the modernization of its older data centres, reducing refrigerant gas leaks” (Scala 2023, 23). The success in Scope 2 is attributed to having “consistently relied on 100% renewable energy

certified by I-RECs.” Scope 3, in turn, represents the highest percentage of emissions across all periods. This is explained in the report by the “construction of new data centers and the improvement of the measurement process,” as well as “emissions linked to the supply chain, that is, what is not in the company’s operational control.”



Intensity of Emissions							
	2020		2021		2022		2023
Scope 1 ($tCO_2e/MWhIT$)	0,00697	191%	0,02026	22%	0,02481	-46%	0,01351
Scope 2 ($tCO_2e/MWhIT$)	ZERO		ZERO		ZERO		ZERO
Scope 3 ($tCO_2e/MWhtotal$)	0,03717	936%	0,38492	-3%	0,37382	27%	0,47550
Total	0,04148	858%	0,39745	-2%	0,38971	24%	0,48386

Table 2 - Intensity of Emissions

Figure 5. Intensity of Emissions. Source: Scala, *Sustainability Report 2023*, 22.

As already outlined in the theoretical exploration that preceded the discussion of the reports, the purpose of providing accounts and accountability for results can be understood as a performative act whose effect is not only to satisfy shareholders and public opinion, but also to produce an idea of nature through the relation the data centre establishes with the external environment. This occurs, for example, through the reduction of refrigerant gas leaks—that is, through the reinforcement of insulation between the data centre’s interior space and the outside world. Scope 3, which represents the most problematic dimension of the emissions declared by Scala, is an even more persuasive example of performativity, given that the emissions from the activities described in this scope result from improvements in the emissions measurement process. In other words, activities whose greenhouse gas emissions were previously disregarded now become part of the accounting. This development may be understood as a discovery or unveiling of a previously invisible reality, but that interpretation —while accurate—tells only half the story. Rather than simply documenting facts that “emerge” from technical and human ingenuity, what matters here is understanding how they

become stabilized as artifacts. In the words of Latour and Woolgar, "'reality' cannot be used to explain why a statement becomes a fact, since it is only after it has become a fact that the effect of reality is obtained. This is the case whether the reality effect is cast in terms of 'objectivity' or 'out thereness'" (1979, 180). Similarly, the greenhouse gases detected in Scope 3 certainly exist objectively, but this objective attribute is not natural—it is an artifact. It is therefore necessary to understand how this artifact is presented as a fact.

It is also important to note the unit of measurement used for greenhouse gas emissions: tCO_2e. The "CO_2" refers to the infamous molecule, while the "t" indicates the magnitude of the emission—tons. The "e," in turn, is both simple and deceptive: it is a device that makes it possible to compare the warming potential of different gases, such as methane and nitrous oxide, by converting them into the equivalent warming potential of carbon dioxide. This translation has practical and theoretical effects that are far from trivial. For companies, aggregating different forms of pollution under the signifier "greenhouse gas" provides convenience in the inventory of pollution produced, grouping distinct chemical components into a single category. Once consolidated under a single signifier, greenhouse gases can be accounted for in different ways, most notably as tradable entities in the carbon market. In this sense, "CO_2e" and its volumetric variants can be understood as the product of a "fungible mediation," that is, "semiotic strategies that serve to translate local relations into generic commodities that can be bought and sold at a distance, obfuscating the question of accountability in favor of the formal logics of accounting" (Pasek 2019, 2). Pasek's critique is aimed at the situatedness of environmental harm produced by data centres and the deterritorialization promoted by the REC (Renewable Energy Certificate) market, which counts MWh generated from renewable sources. But we may also ask whether the very fungibility of CO_2 is not itself a way of homogenizing different forms of pollution under the aegis of the carbon market, which recognizes only the issue of the greenhouse effect.

Thus, the fungibility of CO_2 may be understood as the result of "the institutional and technical arrangements that enhance the capacities of human agents for action and cognition [and] the things which are being valued whose materiality influences the modes of valuation that are possible and their outcomes" (Çalışkan and Callon 2010, 2). In the case of carbon dioxide, it has a material existence—for example in aerobic cellular respiration—that precedes the carbon market. However, the existence of this molecule takes on a different dimension once it becomes part of the modern episteme. Hacking (1999) would argue that insofar as the atoms of CO_2 become integrated into a periodic table, are measured by sensors, and become part of disciplines and institutions, their existence is ontologically subjective (30). On the other hand, once framed within modalities of valuation such as the one reified in the REC, CO_2 becomes an object whose existence resides in the categories of knowledge of the subjects who constitute it. Thus, when assets such as an REC "emerge from sequences of transformations, initiated by people, that modify their status" (Çalışkan and Callon 2009, 386), their existence is epistemologically objective (Hacking 1999, 22). It is through the simultaneity of a material and symbolic existence—ontologically subjective and epistemologically objective—that carbon dioxide is at once something that is heating the planet, a business opportunity, and the fulcrum for the critique advanced in this chapter.

Unlike Latour and Woolgar, this research did not follow the emissions measurement process, nor did it come into contact with employees of independent third-party companies responsible for such work. However, it is possible to make inferences from the ways data systematizations and their corresponding descriptions are presented in the different reports selected for analysis. Presenting variations distinct from those found in Scala, Equinix (2023) also details emission trends (Figure 6). More important than comparing the performance of one company with another is noting the kinds of relations established with tCO_2e levels. Scala, for example, calculates the proportion of tCO_2e per MW, while Equinix works with

$mtCO_2e$ ("m" meaning "metric") per million USD. Cross-referencing the Scala and Equinix reports regarding their efficiency metrics for carbon emissions, one could say that CO_2 sits somewhere between currency and Watts.

In other words, CO_2 is a negative value, as conceptualized by Moore, because it demands more energy for cooling as global temperatures rise due to its own accumulation. This negative value is associated both with a medium of exchange (million USD) and with the type of value extracted from nature (Watts, to be detailed in Chapter 4 on energy). By establishing a ratio between CO_2 emitted per dollar or per Watt, these reports imply that the scalability of data centre operations tends to reduce the proportion of CO_2—whether measured in dollars or in Watts—such that the more data centre infrastructure there is, the less relative negative value it produces. If Scope 2—the emissions from the energy cost of running data centres—is where there is the greatest margin for emissions mitigation, one could suppose that an implicit discourse emerges: the future (the only future) depends precisely on activities that rely on the processes carried out under Scope 2.

Environmental data

Metric	Units	2019 (Baseline)	2021	2022	2023
Electricity Consumption	GWh	5,700	7,140	7,750	8,170
Renewable Energy	GWh	5,250	6,770	7,430	7,850
% Renewable Energy	%	92%	95%	96%	96%
PUE (Annual Average)	Quotient	1.54	1.48	1.46	1.42
Energy Intensity	GWh / million USD	1.028	1.084	1.077	1.007
GHG Emissions: Scope 1	mtCO2e	40,700	50,700	40,300	29,000
GHG Emissions: Scope 2 (location-based)	mtCO2e	2,079,000	2,307,600	2,405,200	2,610,200
GHG Emissions: Scope 2 (market-based)	mtCO2e	306,000	254,800	228,200	234,100
GHG Emissions: Scope 3	mtCO2e	1,311,000	1,504,000	1,292,000	1,249,000
Carbon Intensity (location-based)	mtCO2e / million USD	381	355	337	322
Carbon Intensity (market-based)	mtCO2e / million USD	62	46	37	32
WUE (Annual Average; all sites)	Quotient	–	–	–	1.07
WUE (Annual Average; water cooled sites* only)	Quotient	–	–	–	1.63

Energy and emissions are assured to ISO 14064-3:2019 standards for the quantification and reporting of greenhouse gas (GHG) emissions.
* Water cooled sites refer to data centers with evaporative cooling systems

Figure 6. Intensity of Emissions. Source: Equinix, *Sustainability Report FY2023*, 7.

All at once, these reports establish an idea of environment and temporality organized by data centre infrastructure. If what is at stake is the emission of greenhouse gases, then the complex web of relations among living beings across different ecosystems is reduced to the planet's capacity to convert CO_2 into O_2. Thus, the fewer tons of CO_2 produced per dollar or per watt, the greater the value generated by the service provided, since low emissions can be traded in RECs or carbon credits (financial gain), or by acquiring certificates from institutions that audit and standardize ecological practices (symbolic gain). CO_2 thus becomes at once matter and a symbol of fungible mediation of capital (in the form of money) or of labor (in the form of watts, which technically means work per second). In relation to the data centre, the environment becomes a soft machine, whose materiality prevents the same scalability that shareholders impose on the infrastructures in which they hold votes and profit shares. The proliferation of data centres, in turn, is not only an imperative of contemporary human life—ever more dependent on digital services[9]—but also the solution to the climate crisis, if the crisis is understood solely in terms of global warming.

Taking the Anthropocene as a discursive topos guiding the actions described in ESG reports, the performance presented by these companies places data centres in an ambiguous position. If, technically, an increase in operations means a relative decrease in greenhouse gas emissions (considering, of course, investments in innovation, good cooling practices, electricity use, and renewable energy consumption), then the assumption is that the more data centres there are, the more value is produced and the less CO_2 is generated (relative to other kinds of activities, it bears repeating). At an event on energy issues in data centres that I attended, an operations manager from one company described the development of the data centre market in Brazil as a line resembling an arithmetic progression, which seemed to be a

9 https://www.newsweek.com/clifford-stoll-why-web-wont-be-nirvana-185306

favorable prospect, since it indicated growth. However, this information was a ruse, because the expectation he considered satisfactory was actually one of exponential growth, such that data centres would proliferate to consume the country's entire energy potential.

Thus, even if CO_2 emissions are proportionally lower, such an expectation now evokes—under the heading of "carbon dioxide"—Jevons's paradox (1878), which shows that increases in the efficiency with which a resource is used can lead to greater total consumption of that resource, rather than less. Ultimately, this drive for growth carries an ambiguity regarding the temporality in which data centres operate in the Anthropocene. For the pace of emissions to fall, the pace of constructing new facilities must intensify—and therefore so must the intensity of electricity consumption.

Circularity

There are still other efforts to make data centres environmentally neutral. These efforts include projects aimed at mitigating the production of material waste, such as OData's "Zero Waste" initiative, which seeks certification under UL ECVP 2799 (Environmental Claim Validation Procedure for Zero Waste to Landfill). A similar effort is made by Ascenty with its Aterro Zero program, which, according to the company, prevented 91% of materials such as hardware from ending up in landfills. Regardless of the success of initiatives like these (Lumen, for example, shows an uneven performance in waste disposal from 2020 to 2023), there is a clear effort to achieve a circular logic for discarded materials in which, ideally, nothing useless or harmful accumulates. In the visits I made to data centres, this aspect was not particularly emphasized by the guides presenting the facilities, and in only one of the companies did the waste disposal area occupy any noticeable part of a corridor.

This research did not include the recycling and disposal chain for equipment. However, Myra Hird (2022) offers a critique of recycling culture and practice that is relevant to this aspect of ESG reporting. According to Hird, there is a discourse and economy surrounding recycling that transfer to the individual the duty and responsibility of caring for the waste they produce, creating the impression that progress is being made through this effort. Furthermore, the idea that recycling implies less production of goods and inputs—and therefore less pollution—is misleading. This is because even materials such as plastic require additional inputs, including the hydrocarbons from which they are synthesized, for recycling to occur. Data centre companies are not individuals, and the recycling chain in which they participate may differ from the one Hird studied. Nonetheless, the discourse of individual responsibility—mutatis mutandis—is performed in these reports.

Together, the linear time of implementing new data centres and the circular time of recycling waste compose complementary imaginaries of sustainability. Each temporality refers to a type of materiality: the linear deals with aspects intangible to human senses, such as the electrons measured in watts and the molecules of CO_2; the circular deals with waste that is handled, sorted, and, whenever possible, transformed into a new object with minimal stress on the environment. Such is the promise of data centres.

Conclusion

This chapter establishes two points that will shape the approaches taken throughout the dissertation. The first, epistemological in nature, does not seek to “unveil” a hidden truth behind discourse. Instead, it proposes that discourse be taken as a trace of practices that have a concrete and effective dimension in the world. In doing so, it avoids materialist determinism—whether stemming from a fetishization of the non-human or from a totalizing anthropocentrism. Questions about a first cause of a given phenomenon or about the primal

nature of reality are not of interest to this dissertation; likewise, the counterpart of determinism—constructivist relativism, isn't adequate either. As discussed by Hacking and developed by Latour and Woolgar, the proposal is that matter, whether a CO_2 molecule or billions of electrons in motion, acquires meaning and function through:

a) discourses that describe and justify it;

b) technologies that measure it and set it in motion and;

c) the people who operate those technologies.

This chapter dealt with discourse, while the chapters that follow will also address the technologies and their operators.

The second point begins to unfold an important element of the central argument of this dissertation: the inseparability of sociotechnical assemblages, temporality, and environment. The temporality of the Anthropocene is marked by the acceleration of productive processes, such that there is a disjunction between the rhythms of extraction from nature and its recomposition—that is, the metabolic rift. This acceleration is evident, for instance, in the growing production of waste, as in manufacturing and transformation industries, particularly those associated with petroleum. Based on ESG reports, data centre companies argue that this rift ceases to be a problem, since the main externality of the present—greenhouse gases—is mitigated precisely on the condition that more data centres be built and consume more energy. In a society increasingly dependent on data centre services, the self-imposed need for the expansion of this infrastructure becomes a relief for a planet irreversibly warming.

As will be shown in the following chapters, this good news is not as simple as it appears. But even if the modern project of quantifying, equating, and controlling heterogeneous and irreducible aspects of non-human nature were fully realized, the matter would still be relevant. This is because such "success" would represent the supremacy of modern

epistemology over non-modern cosmologies—both in modes of producing-conceiving cosmos and bodies, and in relations between humans and non-humans. Beyond that, if the future of this dying modernity were indeed unstoppable, the limits of imagination and human existence would reside in the procedural recombination of bits, in the conversion of watts to bits to currency, in a society reduced to a topology of users whose world is mediated by algorithmic regimes of control. In a certain sense, the climate crisis is a line of flight, albeit a painful one, through which we may ask whether the tenets of Western knowledge, from which domination over nature and capitalist social relations are situated, are the only ones possible.

Chapter 3 - Between Me and Data Centres, There Where People

Introduction

Chapters that deal with the methodological aspects of a research project invite the author to adopt an introspective perspective on their relationship with the field. This relationship begins in the very textual production of a research project and in engagement with the literature on the topic. To cite Roland Barthes (2009), "writing is the destruction of every voice, of every point of origin" (141) and, consequently, "[t]o give a text an Author is to impose a limit on that text, to furnish it with a final signified, to close the writing" (144), being an ethnographic text no exception. This way, one can think that the ethnographic text "is never assumed by a person but by a mediator, shaman or relator whose 'performance'—the mastery of the narrative code—may possibly be admired but never his "genius" (141). As a performance, the ethnographic text is a play of mediations: by the person who writes the final text, by the interlocutors from the fieldwork, and also by academic colleagues. In this way, the "I" is a fiction that gives order to the narrative emerging from the myriad experiences and thoughts that make up the research.

Foucault (1979), in turn, argues that "the name of an author is a variable that accompanies only certain texts to the exclusion of others" (19), such that its existence enables ways of classifying a text in terms of style and the institutional context in which it will circulate. From this, one may infer that Gustavo Denani, Brazilian, PhD candidate in Anthropology at the University of Ottawa, wrote these words. This subject, in turn, has his existence and authorship corroborated by the bureaucratic apparatus of the University of Ottawa, from the

defense committee to the workers responsible for archiving this thesis. However, between this envelope of metadata and the voice that is performed in the act of reading, there is an unbridgeable abyss. On the one hand, one can verify through the contacts mentioned throughout the thesis that they did make contact with someone called Gustavo Denani. On the other hand, the set of impressions and fleeting moments arising from the field have the text as their medium and only make sense between the reader and the text, with the "I" being merely a token of this effect. Between writing as fiction and ethnographic experience as subjective experience, it is expected from the reader to engage with the accounts that follow with critical distance from the purported discourse of Truth that is usually attributed to fieldwork.

The ethnographic effort of this research sought to articulate the discursive-accounting dimension of the documents produced by this company, as set out in the previous chapter. This chapter explores the spaces and people that make up the data centre milieu. Beyond the data centres themselves, there are offices, surrounding streets, and a handful of event halls. Trade fairs and panel discussions are sites where a "clean" imaginary of data centres is mobilized, with a soundscape as affable as the voices of the people attending these events. The places where servers and GPUs are actually housed, by contrast, have unhealthy noise levels. The ethnographic work around data centre spaces thus has a sensory dimension that helps to understand what kind of (non)life is permitted for operations free of critical failures. Alongside this, the ethnography attends to the visual aspects of these spaces, both in the spectacular production of the idealized images displayed at conferences and in the architectural care that turns data centres into spaces of thermal differentiation.

Another ethnographic aspect of this chapter is the conversations I had with my interlocutors and, above all, the means and conditions under which they took place. Needless to say, approaching a stranger with an equally strange interest raises ethical questions, such as the

asymmetrical positions of anthropologist and native. In the field, this was an issue, but for the opposite reason: my interest in my interlocutors was not reciprocated. Not only could they politely dismiss me, but a considerable share of my attempts to contact them was simply ignored. This exclusion from a social-professional circuit mirrored the difficulty of getting companies to consider a visit to a data centre. The ethnography was therefore also done by attending to the failures of these attempts, which may themselves say something.

One of the purposes of this chapter, therefore, is to highlight the reflexive character of the field and how its imponderables influence the construction of the research object. Since this is a somewhat introspective reflection, this chapter adopts a more conversational tone with the reader, and the use of the first-person singular will be more frequent here than in the rest of the dissertation. This may seem like a minor detail, but the voice of the writing—particularly in an anthropological text—matters. Indeed, when reading, the voice of the writer is always intertwined with the voice of the reader[10]. Hence, the first-person voice is a device that seeks to legitimize an experience or event lived by the author by collapsing the distance between the voice of enunciation and the reality the writer claims to have witnessed.

Difficulties

The first aspect to be addressed concerns the framing that composes the object. I am interested in the political and economic dimensions of digital technology, and the contact during my PhD coursework with topics and authors related to environment and the Anthropocene shaped my decision about the object of study. The choice to focus on data centres emerged from these influences and affinities. However, I could have approached this infrastructure through the externalities it produces, such as the real-estate dynamics that affect residents living nearby. As this is an anthropology of science and technology project

10 https://www.equinix.com/newsroom/press-releases/2021/11/ellalink-collaborates-with-equinix-on-first-ever-high-capacity-subsea-cable-between-latin-america-and-europe

focused on data centres, it was only natural that fieldwork should consist of visiting this type of infrastructure. For practical and strategic reasons, I conducted fieldwork in the city of São Paulo. Beyond being familiar with the city and living there during fieldwork, it is the largest metropolis in Latin America and one of the major data centre hubs in Brazil. This also means it hosts various events such as trade fairs, conferences, and working groups that attract professionals from other parts of the country.

These advantages, however, did not make the work easier. It did not take long for me to learn that data centres are extremely difficult to access. Their discreet and monolithic presence, appearing simply as one building among others when in the middle of the city, or as part of the landscape along with power transmission towers, already signals their character as camouflaged fortresses. Needless to say, this is hardly surprising—after all, data centres are what my interlocutors call "critical infrastructure," meaning they need to be secure and must have redundancy systems to ensure uninterrupted operation. I experienced this realization with a degree of irony, as it contrasts sharply with the openness and engagement with their surroundings expressed in ESG reports. Aware of this difficulty, I treated the effort to gain entry into a data centre as a way of getting to know it. This means that failures, refusals, and mistakes (as well as eventual successes) could all serve as traces that would help me think about this infrastructure and about the people who operate it.

My first attempt involved contacting the customer service departments of these companies, since the sales sector could direct me to a department or employee willing to show me the facility or speak with me. To this end, my contact consisted of introducing myself, briefly explaining the nature of my research, and clarifying the confidentiality criteria regarding the data collected. However, no company authorized a visit, either by explicitly denying my emailed requests or by ignoring them. The fortress-like character manifested itself

unequivocally, forcing me to adapt my methods and diversify my ethnographic approaches. The contradiction between the benevolent imagery presented in ESG reports and the black box I encountered (that is, one that occupies a territory *to soak its resources*) is an example of the "invisible visibility" of data centres (Vonderau 2019, 10).

This challenge forced me to take a step back and rethink my approach. Jenna Burrell's "The Field Site as a Network" (2009) inspired me to construct an approach to this black box by treating it as a point in a network. Her proposal stems from the turning point in anthropology when authors such as James Clifford (1992) and George Marcus (1992) questioned some of the foundational premises of the discipline, particularly the idea of *the field* as the bounded space containing the discipline's quintessential object: culture. Their response was a shift in focus—from circumscribing a field site to tracing the flows of objects, people, and metaphors across multiple spaces. Marcus thus proposes a "logics of relationship, translation, and association among these sites" (1995, 102), which informs Burrell's digital ethnography and, methodologically, this research. In her article and ethnographic experience, Burrell conceptualizes the *network* as a "structure that can be constructed from the observable connections performed by participants" (2009, 189). She systematizes the places frequented by her informants, extending beyond her initial site—a cybercafé—to trace contours that foreground the social phenomenon that interests her. These contours exceed geographic or institutional boundaries while "preserving the quality of irregularity and the notion that the social phenomenon is outlined rather than detached from its context" (190).

My appropriation of Burrell's work was not as an instruction manual but as suggestions toward the graphing of a topology in which what interests me most are the steps taken, not the specific direction. If Burrell's network originated from her contact with patrons of a cybercafé and then unfolded into points and edges across the places her interlocutors led her,

delineating her contour, in my case I chose to sketch a diagram mapping points of "vulnerability" through which I might enter a data centre. In other words, I treated a data centre as a thing (a building, a company) composed of human actors (workers, clients, affected residents) and non-human ones (regulations, machines, energy, information), which in turn connect to other companies and institutions.

The initial mapping I conducted sought to understand how data centres are connected, whether to other infrastructures, businesses, or institutions. A data centre's operation is anchored on three main pillars: connectivity (via internet access or private fiber-optic cables that link a client's server to its headquarters); energy (both from the public grid and from on-site sources, usually generators); and cooling. It is common for data centre companies to subcontract others for, for instance, installing cooling systems, security systems, or even designing and constructing the building. Firms that design entire infrastructure systems (electrical, hydraulic, climate control, security, and other utilities) are known as "turn-key" providers, delivering a fully completed infrastructure to clients such as data centres. Another type of company, not fundamental but relevant to environmental management, is the one responsible for treating discarded materials. Finally, another common connection, especially for larger companies, is with standardization and certification institutions such as ISO, Uptime Institute, and the Green Building Council. Based on this, I arrived at a tentative diagram on which I relied to systematize my future attempts (Figure 7). In this way, I found my first interlocutors by surveying the edges of this network of connections—both to learn about their experiences and perspectives regarding data centres, and in the hope of, hopefully, networking my way into one.

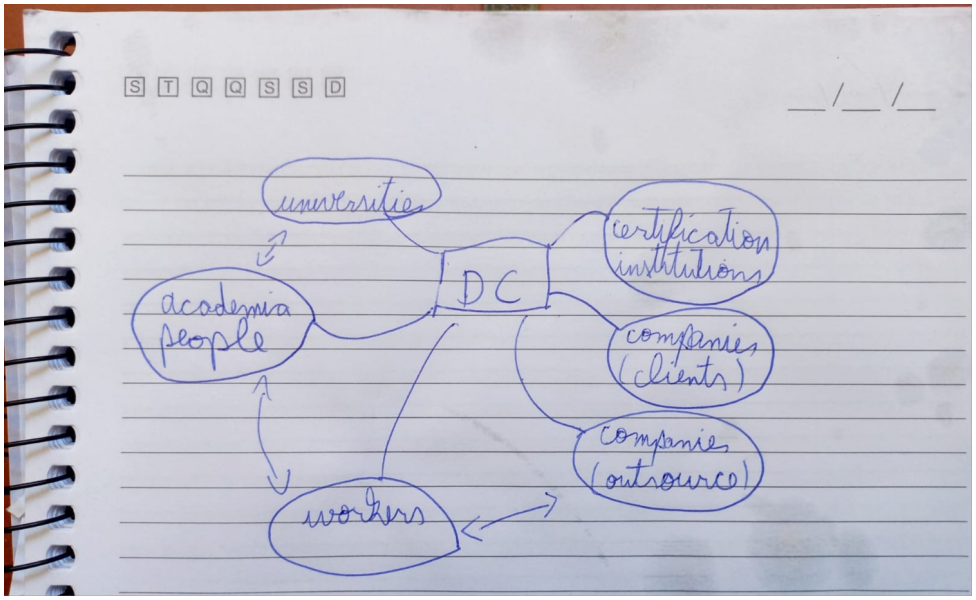


Figure 7. Diagram of the connections composing a data centre, drawn by the author

My initial approach with my interlocutors consisted of open-ended questions aimed at learning about their work and their views on the topics of the research, such as “describe your work” or “how do you imagine the future?” These questions were intentionally somewhat generic, as they would allow for the expression of opinions and desires that might lie outside the initial scope of the project. As a rule of thumb, I recorded the conversations after obtaining permission from the interlocutor, but over time I noticed that their behavior and speech became somewhat rigid the moment I pressed *REC*. In the last conversations I simply took notes on what was said and wrote a narrative of the conversation in my field notebook as soon as it ended.

My first attempt was to contact institutes with branches in Brazil. The Green Building Council (GBC) was the only one that met the criteria and responded to my request. It is an institute whose mission is to “transform the construction industry and society’s culture toward sustainability, using market forces to build and operate buildings and communities in an integrated way” (Green Building Council, 2025). To that end, it is dedicated to training professionals and implementing practices and technologies that make buildings less harmful

to the environment. In the case of data centres, one possible application is architectural design that makes internal cooling more efficient. I had relative success in this endeavor, and conducted three initial interviews: two with professionals associated with sustainability-oriented institutions, and another with a technology director who provides internet-related services.

It was through initial contact with GBC that I received a reply from one of its directors, who agreed to speak with me online, as he was completing graduate studies outside Brazil at the time. An architect by training, he became involved with GBC Brazil nine years ago, drawn by the idea of creating a tool that brings everyone to the table to speak the same language for large-scale projects. It is interesting to note that this personal motivation is precisely what Easterling (2014) identifies as the project of what she calls global meta-organizations such as ISO. Whereas ISO offers standards for technical and management processes that, according to her, pursue a universal ambition through quality as a criterion, one could say that GBC aspires to sustainability in buildings. My interlocutor defines sustainability as mitigating environmental impacts while creating better spaces for people and offering economic gain for investors. This definition, which articulates economic gain with quality of life, aligns with his understanding of what "the market" is. I asked him specifically how he understands what the market is, given that GBC's mission mentions "market forces" as the means for the changes it aims to achieve. He sees the real estate market as the "articulator of resources" for the construction of cities. It drives demand for materials, prioritizes land with access to infrastructure, and influences financing. This definition foreshadowed a formulation that other interlocutors repeatedly used to describe data centres: they are "made" of only two things, real estate and energy.

Another important impression from this conversation with the GBC director was his concern with the pace of the changes he believes are necessary to slow climate change. This, according to him, is partly due to local specificities, as in the case of São Paulo, where high demand allows developers to build anything and it will sell, as well as cheap labor for traditional construction methods, which removes a key driver for process innovation. He thus notes a reduction in the overall incentive for innovation in the construction industry, which has shown very little innovation compared to sectors like automotive or agriculture, often described as having productivity levels behind even those of the hunting industry.

Similar pessimism was expressed by my second interlocutor, whose contact was provided by the GBC director. Again, the conversation took place online because of his graduate studies in the Middle East. Concurrently with his studies, he works part-time for a consultancy in green economy investments. He also serves as a consultant for the United Nations Development Programme (UNDP), focusing on sustainability criteria for data centres. Part of his pessimism stems from a critical view of the very meaning of sustainability. According to him, "sustainability" has largely lost its explanatory value, becoming vague and polysemic. He traces its origin to discussions on the "limits to growth," which aimed to ensure the continuity of economic development in an ecologically sound way. However, modern appropriations have diluted this meaning, allowing "basically anything" (Interview with Paulo, by author, Zoom, October 31, 2024)[11] to be called sustainable.

Regarding data centres, he highlights a global concern about their exponential growth in energy consumption, which is projected to double from 2% to 4% of global electricity consumption by 2026. This growth poses a major problem for countries heavily dependent on fossil fuels. Brazil, however, presents a different scenario because 90% of its electricity is renewable, primarily due to the extensive hydropower capacity developed since the 1970s,

11 https://www.youtube.com/watch?v=rRMAFsuttno

supplemented by wind, solar, and biomass. This makes Brazilian data centres significantly more efficient in terms of carbon footprint compared to those in countries with fossil-fuel-heavy energy mixes (he compared it to China, which is below 30% renewable, and the UK, around 60%). Also according to him, despite Brazil's advantage in clean energy, the global sector is concerned with how to grow rapidly while reducing energy intensity and carbon footprint, especially with the rise of demanding technologies such as AI, cryptocurrency mining, and autonomous driving. There is also a strong economic incentive for efficiency: energy typically accounts for one-third of a data centre's total lifecycle cost.

Additionally, he explains that the entire operational process of a data centre is built for uninterrupted functioning, and this will "never be sacrificed in the name of sustainability" (Interview with Paulo, by author, Zoom, October 31, 2024). This creates a fundamental contradiction: ensuring continuous operation, often to protect against climate-related disruptions, relies on practices that contribute to climate change. This inherent conflict is a major reason why the sector is so concerned about the source of energy, seeking clean power to sustain increasingly large and demanding operations. He gives the example of a single AI data centre potentially consuming as much as 200 MW, underscoring the massive scale of energy demand.

Finally, when asked about his expectations for the future, he holds a pessimistic but nuanced view, stating that "the optimist is ill-informed" (Interview with Paulo, by author, Zoom, October 31, 2024). He sees many reasons for serious concern, extending beyond environmental issues to security and the future of democracy. He refers to a framework of "Four Visions of the Future" (also known as "Visions of Alternative (Unpredictable) Futures and Their Use in Policy Analysis," by Robert Costanza, 2000):

a) *Ecotopia*: Humanity achieves enlightenment and lives in complete harmony with nature;

b) *Big Government*: Society does not reach enlightenment, but strong government regulation mitigates the worst catastrophes;
c) *Star Trek*: Human greed and destructive tendencies persist, but technological advances (e.g., nuclear fusion) solve major environmental problems;
d) *Mad Max*: A catastrophic, apocalyptic future where neither enlightenment nor technology resolves problems, leading to a barbaric society.

He believes that elements of all four scenarios are present in reality, noting positive trends such as growing climate awareness among youth and promising technological developments, alongside ongoing institutional challenges and signs of impending catastrophe.

The third interviewee, the technology director of an internet services company, was the person who enabled my first visit to a data centre. This was possible thanks to favorable timing and his generosity: because the company provides digital services, most employees work from home and are scattered across the country, so one of the few opportunities for an in-person gathering is at the end-of-year festivities when they meet at a rural property. In the year of my fieldwork, a visit was also scheduled to one of the data centres that hosts their files and applications. The details of my conversation with him will be analyzed in the chapter on information, and the visit to the data centre will be addressed later in this chapter.

After these three interviews, I became attuned to events that might take place. In particular, I paid attention to two institutions that I judged relevant in the field: Data Center Dynamics (DCD), with a global scope, and the Brazilian Data Center Association (ABDC), with a national scope. The next section of the chapter deals with my experience at a DCD event.

Data Center Dynamics Connect

If data centres are like fortresses that control everything from the flow of air and electrons to the movement of people and equipment, it goes without saying that the uncertainty of meeting their workers (and the anxiety about a possible failure in this attempt) were feelings that marked the beginning of my fieldwork. Of course, a simple search on Google or YouTube yields videos and reports featuring employees explaining how servers are cabled, how temperature is maintained, how energy is guaranteed. However, these descriptions are nothing more than the company's voice which, much like in ESG reports, crafts a cohesive script about its operations.

Thus, questions about these people require fieldwork: Who are these workers? Where and how can one find them? How and why would they agree to be part of my research? The unsuccessful formal communication with the companies proved unviable, as the interest of a researcher simply does not arouse the solidarity of their sales departments. Much like Geertz (1973) and the cockfight that allowed him to witness the processes that composed the interstices of Balinese culture at the time, I needed an event that would place me in contact with the actors who form the data centre milieu in Brazil. Such an opportunity arose in the form of a convention that brings together professionals and service providers relevant to data centres.

Data Center Dynamics Connect, an event promoted by the organization Data Center Dynamics, which aggregates information, news, and professional qualification resources in the field, took place on November 5 and 6, 2024, in a region of São Paulo that hosts business centres and luxury condominiums. Its purpose was to foster business between companies and networking among industry workers. Registration for the event required the use of an app that generated a QR code to be scanned by an attendant at the reception, who then printed a badge with the participant's name and the company they represented. There were different

categories of access, with the free pass (the one I obtained) granting access to the main hall. Those who paid for a ticket had access to other spaces, such as the negotiation room, where briefings on the data centre market were presented, and a room dedicated to wine tasting. The details of registration, the environment I had access to during the event, and the people present will be described in enough detail to show how a specific kind of corporate sociality is performed.

The public (predominantly white and mixed race men) was heterogeneous in terms of the roles listed on their badges. Their attention was focused on booths presenting the latest server rack models, immersive virtual reality demonstrations of data centre environments, scale models of cooling systems, among other products and services. In addition to the company booths, there were two event stages with chairs, headphones, and two speakers, as well as a smaller stage. In this circular event hall, there were also counters with coffee, water, orange juice, grains, cookies, and lunch served at noon. Catering staff, usually black women, maintained and cleaned these spaces. The environment was well air-conditioned, and the ambient music, alternating between smooth jazz and radio hits, made the place feel like a mixture of a party and a shopping mall.

It was at this event that I first encountered a category relevant to the research: the “player.” This term refers to a person or company with relative agency in the market and with sufficient prestige that their opinions are heard. Typically, people with this status are in managerial positions in companies, with many years of experience and successful projects. The vast majority of the interlocutors I spoke with can be considered players.

During the two days of the event, I felt an ambivalent sense of being comfortably out of place. The environment, as described above, was as neutral as the dress code worn by the participants: dress shirt, khaki pants, and shoes. At the same time, the booth staff were eager

to answer my questions, even though my badge and the type of questions I asked made it clear that their attention to me would not translate into sales. A pair of representatives from a building insurance and monitoring company, for example, explained to me a system for buildings in which sensors function through the Internet of Things. The data captured by these devices (about temperature, electrical network, and other variables) fed an artificial intelligence model hosted on Microsoft Azure's cloud service, which predicted possible accidents and optimized the use of resources such as energy. This highlights the different dimensions of security and how they tension issues of sovereignty. The predictive intelligence is a service provided by an American company, operating in Brazil, whose data is stored in a data centre located in São Paulo but owned by another American company (Microsoft).

Another contact I had was with a pair of directors, one American and one Brazilian, from an American company that provides thermal utilities for data centres. The American director had just given a talk on thermal efficiency, and I was still trying to have a conversation that might give me some deeper insight or, perhaps, a contact that could get me into a data centre. Among the points they shared with me, the ones related to energy caught my attention. The American director told me that one of the problems in the U.S. is the lack of real estate due to limited access to the power grid. Additionally, he mentioned a case in which residents of a town in Virginia resisted the installation of a data centre, and according to him, the community did not even know that the plans involved the construction of a small nuclear plant to supplement energy consumption.

Another dimension of this event was the digitally mediated one, through the app attendees were required to use. Besides conditioning entry to the event, as mentioned above, and containing information such as the venue map and presentation schedule, its home screen had

a feature that caught my attention. The first layer loaded in the app was a set of participant profiles, with photo, company, job title, and area of activity. As in a dating app, I could choose whether that profile interested me for scheduling a meeting. If the interest were mutual, the two users could arrange an encounter. Thus, if the map and the calendar contained in the app represented the spatial and temporal layout of the event, the feature that matched individuals with mutual interests abstracted away the natural and random dynamics of meeting colleagues, streamlining negotiation between interested individuals.

The event app was not the only tool used for promotion and engagement. Another behavior encouraged by the organizers was to post photos on LinkedIn tagging the event. Giant screens periodically displayed the posts. Furthermore, it was common for speakers, after their presentations, to meet with acquaintances, engaging in small talk and taking selfies. These mundane aspects, although seemingly irrelevant, are formative of a logic and professional ethos of this milieu.

Networking

This section addresses a specific mode of sociability in late-capitalist professional environments: networking. A preliminary definition of networking—one that will be problematized in the paragraphs that follow—is that it consists of meeting strategic colleagues in a professional field, and, more importantly, making oneself known to them. This practice generally occurs in para-professional moments and spaces where one is not working within the company itself but in contexts of exchange between workers, such as parties, conventions, and conferences. The Brazilian Association of Data Centres, for example, organizes monthly happy hours that mix socializing and networking. Above all, it is in the interstices of major events—between presentations and at lunch—that networking

interactions occur. But before analyzing what it is and how to take it as an ethnographic method, I will describe the subject who performs this practice.

One could say that networking is a specific sociability of the entrepreneur of the self (Foucault 1979) in its contemporary version, in which sociability itself is an investment in which social capital and opportunities for professional success are intimately intertwined. In *Liquidated* (2009), Karen Ho mentions the term as a trivial vernacular element in the context of financial markets. According to the author, networking was important for "imbib[ing] the general, taken-for-granted language and landscape of Wall Street, usually gathered during intense participant observation, as well as to establish a web of informants for 'actual' fieldwork" (Ho 2009, 15). In this sense, networking is a practice that renders porous the boundary between work contexts and those of leisure and sociability. Over the course of her research, Ho shows how networking can serve both to explore new professional opportunities and to "serve as a form of protection, albeit one that often interferes with career goals and mystifies power structures" (Ho 2009, 115). Whereas Ho makes these power structures explicit in terms of alma mater cliques and male sociability, such as in the context of strip clubs, my fieldwork experience displayed a different dynamic. The Brazilian Data Centre Association, for example, organizes monthly happy-hour events in venues such as pubs without a markedly sexist orientation. This does not mean, however, that gender parity is greater than in the context explored by Ho.

Also researching financial market actors, Caitlin Zaloom describes constitutive aspects of networking as a specific mode of sociability, even if the term itself is not explicitly mentioned. In *Out of the Pits* (2006), a study of the Chicago Board of Trade (CBOT) and the implementation of electronic trading, Zaloom mentions cases in which networks take on a less pragmatic and more organic character, even while oriented toward labor market entry:

“Traders growing up in Chicago and its suburbs learned specific ways of engaging the market through networks of friends, family, and neighborhood ties. Members of Chicago’s ‘trading families’ learned about open-outcry methods of competition and strategies in their youth. Thousands of others are connected to the market through looser ties with friends, colleagues, or clients who work at the exchange” (Zaloom 2006, 55). According to Zaloom, these relationships “create channels for career advancement” (2006, 59) and “generate a flow of trades from friends and colleagues that is strong enough to support traders in tough times” (2006, 63).

These excerpts reveal heterogeneous elements that compose a network. The term describes both people connected within a shared professional or social milieu and the space and infrastructure for business at the CBOT. The term “connection” itself denotes a specific type of social relation: one does not refer to one’s mother as a “connection” within the family, but rather to an acquaintance or contact who can be activated when necessary for a pragmatic purpose. A connection also occurs when two or more devices link under a shared technical protocol, such as Bluetooth or TCP/IP,which enables communication between computers and access to the internet via a browser. Thus, throughout Zaloom’s work, the term “network” is commonly applied both to the architectural and technological aspects of the CBOT that constitute the material space for information flows and to the various sets of relationships among her informants. This dual meaning of network, encompassing both human relations and technological couplings, is symptomatic of a mode of sociability that rose to prominence around the time of Ho’s and Zaloom’s publications, alongside the adoption of smartphones and social media.

The absorption of technologies into social relations does not, by itself, explain networking as a form of sociability oriented toward professional contexts. Rather, networking is set in

motion by specific circumstances and needs characteristic of the contemporary professional-managerial class. Ho, for example, states that "job security does not exist" and maintains that investment banking was "the most insecure of all professions" (Ho 2009, 231), while the workers ethnographed by Zaloom "push the possibilities of annihilation of the self through economic risk-taking" (Zaloom 2006, 109). Although workers in both contexts are not financially marginalized, this type of white-collar worker—predominant during my fieldwork—experiences labor insecurity. Expanding possibilities for job mobility by leveraging professional contacts thus becomes a resource for mitigating such precarity.

In this way, my fieldwork experience witnessed an iteration of the homo oeconomicus whose members see themselves as an enterprise, whose investment lies in cultivating their skills, and their networks. If this version of the entrepreneur of the self sees in his concrete condition the image of an entrepreneur, one could say that body and capital are its constitutive and inseparable terms. Part of the desired subjectivity in this sense is articulated in the talk given by an operations director from a large Brazilian data centre company. He advocates for a culture of continuous training based on certifications, which he understands as part of a process of "knowledge recycling." Additionally (and, in a certain sense, contradictorily), he sees the need for accelerated professional maturation, thereby emphasizing the innovative character that permeates the data centre sector. For this, there must be coordination between the employee's individual dedication—who must prepare to obtain certifications—and the guidance of their manager. The acceleration required to acquire competencies and a cognitive-motor capacity always adaptable to new technologies and labor processes are topics that would return again at another moment of fieldwork. This speaker seemed to be a relevant contact who could inform me about both the type of subject he helps shape and the type of subject he himself became in this milieu. Thus, I waited for his presentation to end, waited for him to finish talking to his acquaintances, and intercepted him.

I obtained his phone number, but after repeated attempts to schedule a conversation, his schedule did not allow it (or so he justified it to me).

Broadly speaking, all the contacts I obtained for conducting the fieldwork, when not strictly circumscribed within networking practice, required elements I did not possess or was not adept at performing, such as etiquette (corporate modes of greeting, the conspicuous use of business cards), goals (career opportunities, acquiring information about a specific company), and, above all, being a *player*. These shortcomings made my initial approaches to participants at that event difficult to convert into more lasting contact, such as that with an operations director (one of the few women speaking at the event) whose work I expressed interest in and whom I should now turn to.

Simulacrum

One of the presentations I attended was given by an operations director of a data centre located in Brazil's Central-West region. The topic was a project by her company aimed at prospecting young talent in a public school. The project was justified by the need to create a workforce for the Brazilian data centre market, as the supply of workers must keep up with investment levels, and also to make the industry less opaque for people not already involved in it. With this, according to her, one could show how interesting it can be to work in a data centre and offer these students, who generally grow up in adverse socioeconomic conditions, the chance of having a career. In one of her slides, which showed an image of a woman wearing a VR headset, she emphasized the need to open the eyes of low-income youth to the sector. The overlap between "opening their eyes" and the image of someone with their eyes literally enclosed by a VR headset was too much for me to contain a laugh. However, I laughed alone.

Beyond a mildly awkward situation, that moment prompted me to reflect on the image regime of that particular event and of the data centre professional milieu more broadly. It was common in presentations to have title slides with images that by attempting to synthesize discourses and expectations that drive the sector, bordered on science fiction and the absurd: depictions of data centres isolated in the middle of the Amazon rainforest, or the common trope also found on company websites: dark server aisles illuminated by neon lights, with a person (or sometimes a being made of light and binary code) holding a holographic tablet with graphs and numbers. One can say these images are merely illustrative, meant to seduce the eyes while the speaker's voice finds its way to the audience's ears. However, they are a bit more than that.

In a subsequent presentation, the sales director of a major GPU manufacturer argued against the supposed demonization of AI due to its high energy consumption. According to him, both the density of GPU boards per rack and the amount of value generated per watt by these boards are increasing. With this, he proposed an alternative to the Power Usage Effectiveness metric: *token per watt*, with *token* referring to the output a model (such as a generative AI model) can produce. This description is important because it situates data centres within a productive context distinct from their more general purpose, namely, storing data, running client applications, and transmitting information. This AI context turns data centres into something like an "AI factory," which represents a further step in a digital production chain. This is because, unlike a typical end-user AI experience, such as entering a prompt to generate text or an image, an AI-specialized data centre would produce the models themselves to meet different kinds of demands, ranging from generative uses, as in the cases most familiar to the public, to predictive routines for surveillance purposes, machine vision for logistical control, among others.

Thus, he argued that although a GPU consumes more energy in absolute terms than a CPU, it delivers more product, and therefore more value, than a CPU. In other words, GPUs densify the space of a data centre, making it more energy-hungry, while at the same time increasing the variability of possible products, since these are products (AI models) that themselves produce products (images, inferences, motor responses of automata, and the list goes on). In view of the many gains for economic productivity and the progress of humanity, the cost he points to (measured in tokens per watt) becomes, even if more energy-intensive in absolute terms, a bargain for those who believe in his argument. The Jevons' paradox returns, now in its AI version: indeed it consumes more energy than other modes of computation, but if it delivers more value, then it is preferable than .

It is worth recapping some impressions reported in the paragraphs above: data centre companies draw on imagery that, as the indicators in ESG reports attest, reinforces the relationship between the environment and technological development. Such development, in turn, proceeds through the production of new technologies and aims at the production of value. As a lifeline for this end, electricity becomes the means of reducing costs through efficient use and expanding value by increasing investments according to market demand. Thus, the more investment in digital technologies (i.e., those that can exist without consuming fossil fuels), the lower the environmental degradation when compared to other productive chains. For an outside observer, this logic could be understood as cynicism or empty talk, reinforcing a tacit consensus about capitalist logic, for example, the need for cheap labour and cheap energy to be exploited by capital. Certainly. But simply dismissing the participants of these discourses and images as people alienated by the very discourses they articulate is a solution as simple as it is contradictory for someone who intends to take them seriously as interlocutors. Thus, returning to the presentations mentioned above, nature becomes something between background and hostage to the wonders that more

computational labor can produce. More than that, nature, in its various representations in booths, slides, and logos, exists in this milieu as simulacrum, that is, it is composed of images that mask and denature it, then mask its absence, and finally exist through the relations between images of what it no longer is (Baudrillard 2019, 6).

One might argue that the mere symbolic representation of the environment in images and discourse could be understood simply as ideology, without needing to invoke a post-structuralist philosopher and his convoluted logic. However, the transformation of nature into symbols is only part of this process. These images, discourses, and, in the case of ESG reports, data, refer to the idea of nonhuman nature, representing it as absence. In other words, elements of nature associated with a pristine landscape are not part of a data centre; they are absorbed by it, as in the case of the various energy conversions derived from the environment. This absence, even when performed by companies and in these events, is produced, for example, in its conversion into energy, labor, and value. Energy and labor, as will be explored in the next chapter, are modes of what remains of nature after capitalist exploitation. Events such as DCD Connect merely render these signs into a total language of what conventionally gets called nature, even if its presence is purely spectral. Even if logically dubious, this language expresses a virtuous circle of value production in the terms of an economy that proposes to coexist with ecology, and can thus be uttered and heard as common sense by their participants. In this way, the nature shared among these players at DCD Connect isn't solely symbolic or allegorical, but as real and meaningful as the megawatts counted at the ESG reports. At the same time, this idea of nature shared by them has nothing to do with the beings composing the non-human set of elements composing the modern idea of nature, environment, or ecosystem.

The simulacrum, however, is not limited to nature: it extends to the entire event through the infrastructural performance of its functioning, not only in the regime of signs it mobilizes. This is because, taken as an infrastructure, DCD Connect is an infrastructure in micro-scale. It facilitates commercial, contact, and information exchanges, while accommodating the bodies present so they may comfortably perform their roles. Like any infrastructure, its functioning tends to conceal the processes of extraction and value production, separating production and consumption both sensorially and geographically. Thus, we can dissociate the meat we bite from the slaughter and dismemberment of the cow it once was, just as I can type these words without lamenting the human and environmental degradation resulting from mining the minerals that compose my computer. Similarly, the event space has an infrastructural logic, in which the labor that maintains that environment (cleaners, waiters, audio technicians) becomes visible only as the sign of its own absence.

How is labor performance the sign of its own absence? This apparent logical absurdity, as I will demonstrate, constitutes the experience of this event, and its functioning recalls the infrastructural logic of labor exploitation. This is because the existence of these workers does not occur solely through their intrinsic attributes and performances, but in relation to the other individuals in that place—namely, those they serve. I and the other participants wore clothes that, even within the aesthetic misery of the corporate world, had some degree of individuality. Added to this were badges that individualized their bearer with a name and company, generating curiosity and encouraging visual contact. These nameless workers, in turn, wore simple black uniforms, and their gestures and actions were always directed toward maintaining the space—cleaning, replenishing food, checking the headphones onstage. They acted in relation to the objects they handled (trash, food, cables, headphones) and to the requests made by us, the audience, or their superiors. This labor—analogous to housework (and tellingly, the majority of workers in these roles were women, compared with the

predominantly male visitor group to which I belonged)—evokes both the reproductive labor that, until the second wave of feminism, was hegemonically feminine, and the invisibility of infrastructures that function without disruption.

Reduced to their functions, these workers exist insofar as they perform the very thing they are supposed to do. In the recursion that opposes existence as a subject and performance, "it is no longer a question of the ideology of work—the traditional ethic that would obscure the 'real' process of work and the 'objective' process of exploitation—but of the scenario of work" (Baudrillard 2019, 27). This does not mean that the real has abandoned us and that only an infinite chain of signs remains. If one of these workers were to stop serving participants or allow a trash bin to overflow, the consequences would be very real (or, following Hacking, epistemologically objective). However, in places where signs refer to themselves and no longer to the techniques and architectures of microphysics of power found in disciplinary institutions, the real ceases to be constitutive of experience, and what is performed and articulated—whether by precarious workers collecting trash or a manager with a six-figure salary—are part of the simulacrum. Analogous to Baudrillard's observation about prisons, the case of DCD Connect, by emphasizing data centres as a specific site of quantification and computation, conceals the fact that society as a whole is already data-centric.

Perhaps the very urbanistic tragedy that is the city of São Paulo acts as an antidote to partially dispel the spell of the simulacrum. Leaving the events hall and going back home means dealing with the chronically fetid Pinheiros River, seeing favelas on the opposite bank, and navigating a train line that, after privatization, suffers constant breakdowns. The final balance of this event, despite the experiences described above, was frustrating. The two managers whose contact information I obtained did not turn into interviews, whether due to scheduling issues or simply failing to respond to my emails.

Unicorn Data Centres

It is precisely along this same train line, skirting the same foul-smelling river, that my next journey begins. Weeks after DCD Connect, I was leaving an event hosted by the Internet Steering Committee (CGI), an independent, non-governmental technical body that supports the standardization and improvement of the internet in Brazil. My destination was one of Unicorn Data Centres's data centres, located in Barueri, a city to the north of São Paulo. It bears repeating that this visit was only possible thanks to an interlocutor whose company was scheduled to visit the facility; I was invited to join. Like me, most of the other visitors had never been to a data centre before.

Before addressing the visit itself, it is important to have a sense of the surrounding space and the people around it. Barueri is not served by train or metro, which meant taking a bus from the terminal located at the end station of the train line I was on. The trip, lasting less than an hour, passes through a predominantly residential area. The first blocks are relatively wide streets, houses and mid-sized buildings on reasonably spaced lots, and neatly organized power and internet lines. As the route progresses, one enters a peripheral area where the streets are steep and poorly maintained, and the electrical wires form a chaotic tangle with loose ends. Although there are no tall buildings in these neighborhoods, the lots are densely occupied with one- or two-story masonry constructions, generally built continuously side by side.

It is not difficult to identify the street where the data centre is located: it cuts across a massive block occupied by two logistics companies and several data centre buildings, three of them still under construction, drawing attention with their sheer scale. What also stands out is that, unlike locations with few residents or cities where economic decline makes data centres seem like an illusory salvation, these facilities are situated in the middle of a lively neighborhood

with houses and small shops. I asked passersby if they knew what those buildings were. No one gave a convincing answer, but one older man, drinking cachaça at a bar, told me he had watched the buildings being constructed—that is, people were already living here long before this complex of data centres was built. This represents a very different context from those described by the authors in the literature review: these infrastructures settled here with relative ease, benefiting from utilities that were already in place. I could not extend my conversations with this man or others, as I could not risk arriving late for the visit.

The entrance to the street looked like a large construction site, with contractors coming and going alongside trucks carrying building materials. There was a security post, but I passed without difficulty. Surveillance cameras covered various angles of the street, which contrasted with the absence of signage, forcing me to orient myself using Google Maps. I arrived at the building 15 minutes before the scheduled start of the tour—at my interlocutor's request—to allow time for registration. I reached the entry patio and introduced myself to a receptionist who, behind opaque glass, asked for my ID. I presented it and explained that I was joining a guided visit with the company that had invited me. A few minutes later, I passed through a rotating door that granted access to the building. Inside, again, there was a pair of security guards behind glass. I showed them a QR code my contact had sent me, which supposedly granted access to the building's interior. But the guard said the tour had already started and asked me to wait again. When I thought my attempt would be thwarted, my interlocutor appeared. We passed through an antechamber with a fingerprint-access display—though it wasn't required, as the door to the corridors with servers opened automatically—and we hurried to join the group. A small victory, I thought.

We were a group of ten people and two Unicorn Data Centres employees guiding our steps and explaining the site's details. The corridors did not have raised floors—in other words, the

rack cabling does not run beneath the floor but is instead organized along suspended structures above the racks. Various devices, such as the sprinkler system and fire alarms, follow an N+1 redundancy standard, meaning there is always one extra unit in case the primary fails. We were also shown the diesel generator, which guarantees 75 hours of operation in the event of a power outage. They mentioned that in November 2023 the main air conditioning system could not handle the intense summer heat, making it necessary to use the diesel generator to supplement the energy needed for the additional cooling units. In other words, equipment supposedly reserved for extraordinary events had to be used precisely to deal with abnormal heat brought on by the climate crisis.

Alongside the expected incessant buzzing of air conditioners and server fans, there were pipes connected to a dial gauge I could not identify. The guide told me it was a manometer used to measure the pressure of cold air being pushed into the racks. He explained the CFM metric (cubic feet per minute), which varies according to temperature and humidity. According to him, these variables affect air density, determining the amount of force the AC system must exert to cool the machines. With this, he said, they achieve fine control over airflow, since the airflow velocity reaching the customer's components is stipulated contractually. I commented that I expected the environment to be colder. He explained that excessive cold can also be harmful, as it makes the air drier, causing chips to crack and increasing the likelihood of static discharge.

These details are not meant to bore the reader. Each of these techniques and manipulations of atmospheric and energetic variables constitutes the internal environment of the data centre. This environment, in turn, is organized to serve the equipment, which must operate efficiently. Up to this point we have a technocentric description in which technology follows its own internal logic, capturing living beings who then inhabit the world according to its

recoding. This is not inaccurate, but it is not sufficient. What lies beyond this will be discussed in later chapters. For now, one last account from this visit: upon entering the generator room, we came across three massive green Cummins generators, ten meters long, covered in buttons and inspiring a sense of awe among the group. Like tourists waiting for a natural phenomenon, we waited for one of them to run its routine cycle to prevent oil stagnation. While waiting, I noticed a small wasp on the floor, already dead. I found it curious that even in controlled and enclosed environments, cracks still emerge. Weeks later, a fire broke out in that data centre, and all the safety measures, care, and predictability presented during the visit revealed their fragility. The wasp was probably not the culprit.

Peekaboo Telecom

One misfortune is another's opportunity. The accident mentioned above appeared on the LinkedIn page of the second data centre I visited—precisely as a way to promote its safety. I learned of Peekaboo Telecom by exploring a point of entry in the connectivity diagram I had created. Studying informational infrastructures, I learned that overlap between data centres and Internet Points of Exchange (IPX) is common (IPX will be detailed in the chapter on information). The website of the Internet Steering Committee keeps a list of IPX locations, including the last data centre I visited. I emailed the addresses listed there, and this company agreed to receive me. Its location inside a shopping mall struck me as odd, as I was accustomed to whole buildings dedicated to such activity. I visited this data centre twice. The first visit will be discussed in the chapter on information; the events of the second visit align more closely with the themes of this chapter.

The purpose of the second visit was to clarify doubts that emerged after the first. Additionally, the CEO and CTO, longtime friends and colleagues, produce a significant

amount of YouTube content featuring the company. I suspect this drive for self-publicity made them accessible to me. Unlike the previous visit, the mood was less light and more formal. Carlos, the CEO, was frustrated by a failed negotiation with a client, which he blamed on a poorly crafted proposal by someone in his sales department. According to him, it was becoming increasingly difficult to find competent professionals with the experience necessary to perform their roles adequately. Andrei, the CTO and Carlos's business partner, expanded on this frustration with a pessimistic assessment of his experience. He said that the employees he supervises have a very limited learning memory—"if they learn ten procedures, by the time they learn the next one, they've forgotten the first." Added to this, according to Andrei, is a lack of interest in studying independently and learning theoretical fundamentals, which he attributes to a failure of schools, whose pedagogical project teaches students not to think but simply to follow orders unreflectively.

Above all, there was a sense of hopelessness regarding what they called "human material." Still grieving the lost client, Carlos described his difficulty finding a professional profile that met his expectations. He mentioned two candidates he had interviewed remotely, a man and a woman. The former, according to Carlos, had painted nails and an LGBTQIA+ flag behind him, and when asked if he knew what the company did and why he was applying, he did not know the company's sector and justified his application simply by needing a job. The latter, in her turn, had prepared at least minimally and showed interest in the position beyond the need to pay bills, and she was chosen. Beyond her qualifications, Carlos complained about the first candidate, saying that he found the candidate's political stance and appearance irrelevant to the job.

I did not spend enough time with Peekaboo's partners to understand their political-ideological positioning, and even though I hold personal judgments based on my familiarity with middle-

class culture in this region, they are not relevant here. What matters is the similarity between Carlos's argument and what I witnessed at DCD Connect. At the event, the waitresses and cleaning staff have their subjectivity reduced to their function, and this occurs insofar as their subjectivity (among other factors, being women and Black in a country with an institutionally enslaving and patriarchal past) relegates them to lower-wage, lower-power jobs. But within the event's simulacrum, none of this matters, because they exist only insofar as they are invisible in their bodies and visible in their procedures. Similarly, what matters to Carlos is that the candidate's subjectivity be irrelevant, as long as they perform the expected function. It is in this discursive sleight of hand—where a work ethic masks what does not fit into an office (even one with a compliance department) or an infrastructure—that the tension resides.

Finally, this encounter with the owners of Peekaboo Telecom brought to the surface the type of subject that is idealized to operate data centres, adding yet another angle to what I had witnessed at DCD Connect and on other occasions. Aspects that compose what is understood as identity are not explicit issues, nor do they demand a noticeable performance from a Diversity, Equality, Inclusion (DEI) department—indeed, they were barely addressed at DCD Connect, despite the visible minority of people who were not white men. In their place, what emerges is the idea of a worker endowed with abstract potentialities for learning and discipline—someone from whom proactivity and the progressive absorption of ever-innovating technologies is expected. Such absorption, as stated by one of the DCD Connect speakers, must occur at an accelerated pace. Andrei said his frustration in failing to find this type of worker stems from a dysfunctional education system, one that does not produce intelligent people. The next and final fieldwork account in this chapter will provide a perspective focused on this issue.

SENAI

An important moment in the fieldwork was a working group in which I participated alongside players from a little over ten companies, most of them based in São Paulo. This meeting was made possible thanks to my membership in the Brazilian Data Centre Association (ABDC), through which I gained access to events bringing together prominent names in the sector. The purpose of this working group, organized by the association, was to develop—together with the pedagogical coordination of the educational institution hosting the event (SENAI, which I introduce below)—guidelines for courses aimed at training entry-level workers with the skills necessary to work in data centres. This group emerged from reciprocal needs: on the one hand, SENAI, seeking to train professionals who meet market expectations, needed to understand the sector's specificities; on the other hand, data centre companies wanted to increase the pool of workers who already possessed sector-specific knowledge—a need that tends to grow as investments in the sector increase. The meeting lasted one full day, during which the dialogue oscillated between an exercise in collective self-understanding and a negotiation over what companies wanted and what SENAI could offer. To understand the terms of this dialogue and its latent tensions, it is necessary to introduce the institution where it took place.

SENAI (National Service for Industrial Training) is one of the most important institutions for vocational training in Brazil. It is part of FIESP (Federation of Industries of the State of São Paulo), which in turn is maintained by contributions from employers' unions. Its founding in 1942 represents a turning point in the country's educational system, which until then had been oriented toward training liberal professionals from the elite coffee-growing class. Seeking to "unleash the energies of the population that had been sterilized by the old humanist and classical school model of the Old Republic" (Carvalho 2013, 47), its creation

represents the convergence of state interests and emerging elites, who sought both to economically develop the country and to control the class tensions arising from this process.

The courses offered by SENAI are subordinated to the needs of the industrial sector, which—represented by employers' unions—participates along with the institution in composing the curriculum. These councils therefore determine the types of competencies students will acquire in the course. In other words, vocational education produces students in terms of the function expected of them based on the expectations of industry. One might say this implies the production of subjectivity—modes of corporeality, sociability, and worldview. In this sense, a critical analysis of the process of worker formation allows us to understand the type of subject that produces data centres as an environment.

Each SENAI unit focuses on specific areas of industry. The unit where the meeting took place offers courses related to digital technology, such as digital game development, cybersecurity, and fiber-optic cabling. In the 1950s, the decade of its inauguration, its main course was ceramics, serving the needs of the construction industry and benefiting from synergy with the ceramics company owned by Roberto Simonsen, one of SENAI's founders. In the 1970s, the mechatronics program became the flagship course, reflecting the rise of automobile manufacturing and union strikes. In the 1990s, its activities were suspended for renovations, and it reopened in the 2000s with its current emphasis on the digital economy. The choice of this unit for the meeting is therefore apt, given that data centres are precisely the infrastructure on which the workers trained there directly depend.

This history, as well as the unit's dependencies, was presented during the guided tour led by the director. One of the first features he highlighted was that the classrooms do not have individual desks but hexagonal tables. The reason, he explained, is to accustom students to group dynamics in project development. The organization into groups follows the Agile

methodology[12], which is also taught to students. The director quickly clarified these choices: knowledge is only worthwhile if it is useful; otherwise it is, in his words, residual waste.

The classrooms where coding is taught have computers on the tables, and there is no lectern for the teacher. According to the director, this environment flattens the hierarchy between students and teacher, such that knowledge is constructed during class, between teacher and students, rather than transmitted from the former to the latter. This coincides with Carlos's account of his own training when he compared it to a traditional academic formation. According to him, whereas at a university knowledge tends to be cumulative—maintaining the foundations of disciplines and adding new debates and discoveries—practices of applied technology renew themselves more quickly, such that students who already work in the field often help the teacher with the topics taught in class. The vocational classroom is therefore more sensitive to market fluctuations and adjusts according to them. More than that, knowledge constructed in class has practical ends. Thus, a piece of knowledge that does not "ascend" to its practical fullness is "useless" and therefore detrimental to the student's training.

After the institutional presentation, we moved to the room where the curriculum would be discussed. The working group included high-level employees from a dozen Brazilian and foreign companies, teachers from other SENAI units, the SENAI pedagogical coordinator, and his assistant. The meeting began with the coordinator describing his job as that of a mediator between his institution and the sector that demands its services. This mediation consisted of listening to the pains of industry regarding its needs for the type of professional it desires. Constructing the curriculum thus consists not only in listing the techniques, norms,

12 https://diariodonordeste.verdesmares.com.br/negocios/faccoes-cobram-ate-60-do-valor-de-contas-de-internet-a-provedoras-ninguem-consegue-dormir-1.3628108. "A source connected to companies in the sector, who chose not to be identified, reveals that criminal organizations have been demanding up to 60% of the monthly fee from each internet customer in order to allow the provider to operate in certain locations. 'They invade stores, burn cars.'"

and procedures to be transmitted to future workers, but also the level of specialization in specific areas, the time allocated to the program, and the type of body to be formed.

Witnessing this dispute disguised as dialogue was an unusual experience. On the one hand, the coordinator had the mission of collecting the testimonies of the players and, within a few days, synthesizing them into a curricular structure that would become an unprecedented course specifically for data centre training. On the other hand, the players sought to find a consensus regarding pedagogical priorities that could address the industry's shortcomings. This consensus followed a winding path, as different managers from different companies had —as expected—different perspectives on what professional profile should be available to the market. Thus, in trying to articulate definitions that might serve as a metonym for the data centre market, what emerged—much to the coordinator's disappointment—was a confusing tangle of suggestions.

Broadly speaking, the players, unable to clearly articulate what they wanted, asked for everything. In other words, the ideal professional should have transdisciplinary competencies spanning electrical systems, air conditioning, and some knowledge of building maintenance. Skills in cabling and networking were also mentioned. These needs were urgent, and they suggested a six-month course to address the ongoing shortage of labor—again invoking the demand for an accelerated rhythm of vocational training. Another factor mentioned was that data centres are a "mission-critical" environment. This means situations arise requiring not only rapid diagnosis but also swift decision-making and rapid implementation of procedures —often within less than ten minutes. One participant described an early-career experience in which a power surge overloaded a Power Management Module; keeping the power on risked burning the equipment, but shutting everything down would result in contractual penalties due to falling below the minimum uptime. Thus, part of vocational training involves not just

content but readiness to apply specific aspects of knowledge that a given situation may demand.

As noted above, what was meant to be a dialogue revealed itself to be a difficult-to-negotiate antagonism. After the meeting, I remained with the SENAI teachers and coordinator as they commented on what had transpired. Between resignation and frustration, he began by saying that SENAI already offers what they are asking for. A teacher added that the companies wanted a worker with the profile of a postgraduate student but willing to receive the salary of a "peão"[13]. SENAI teachers necessarily have professional experience in the areas they teach, meaning they started as "peões." Thus, one could say there is a latent class antagonism here —expressed, on the one hand, in the accelerationist impulse of the players who want a disciplinarily transversal specialist capable of handling the specific realities of data centres, and, on the other hand, the teachers who have already been such workers and understand the rhythm of learning.

Alongside the class dimension—intrinsic to this and other contradictions between labor and capital—there is also a rupture between two paradigms of subject formation. As noted at the beginning of this section, SENAI was created during Brazil's industrialization period. It is therefore a disciplinary institution (Foucault 1979), even if its pedagogy replaces linear rows of desks with hexagonal tables or swaps modular content for projects structured around Campbell's Hero's Journey. Students are still subjects whose conduct and performance are evaluated, and the curriculum to which they are subjected not only passes through a bureaucratic apparatus for approval but depends on validation from federal bodies to be officially recognized.

13 Needless to say, computers are capable of performing calculations such as integrals. However, they do so using discrete numbers, employing devices to produce results close to numbers that cannot be represented in discrete numbers.

Finally, one of the last fieldwork events was a meeting between the regional director of SENAI and industry players. This event followed the same organizational format as the working group, in that invitations were extended to those who had expressed interest in the WhatsApp group created by the ABDC. As a result, individuals who had not been present at the working group could participate by referral. The main objective was to strengthen ties between companies in the sector and the institution. I arrived just moments before it began, in the corridor in front of the event hall, where a generous breakfast was being served. I recognized some of the individuals who had participated in the working group and introduced myself to others whom I was meeting for the first time. After a few handshakes and some small talk, we entered the event room.

As noted above, the scope of the event was to weave alliances and foster potential synergies between SENAI and data centre companies. In presenting SENAI to the audience, the regional director emphasized that since 2019 the institution had become data-driven—that is, all planning was based on statistical data collected and published by the government and by organizations from different sectors of industry and commerce, informing the formulation of educational policies and other strategic plans. In this sense, it was emphasized that the institution had already been integrated with data centres well before this specific initiative. This remark was part of a broader effort to show that SENAI was more than a school focused on mechatronics and civil construction, as it was also equipped with a quantum computer and a protein printer. Finally, he reiterated that SENAI's mission is to foster cooperation with the country's various productive sectors, and he therefore opened the floor to questions and comments from the audience.

Beyond the usual industry players and the comments already voiced during the working group, such as complaints about the lack of adequately trained professionals, two participants

particularly caught my attention. One of them was a member of the army who, according to his own account, had been seconded by the institution to implement mission-critical projects. He explained that the distinctive feature of his approach lay in a chain of command divided into the pillars of strategy, tactics, and operations, as in the military. While speaking with him after the meeting, another participant standing nearby added that the use of military labor was becoming a trend for tasks requiring hard skills, such as construction, maintenance, and moments of catastrophic failure, whereas individuals trained in hospitality were recruited for soft skills. I was reminded of my previous experience in programming, in which both hard and soft skills were expected of all professionals, and thus I found it difficult to imagine how this division of competencies operated in a data centre context. Given the open and slightly chaotic dynamics of an end-of-event conversation, I was unable to obtain a clear answer.

Another participant who caught my attention was a training manager. His professional trajectory was unusual: he had worked for years in an aviation company training flight crews. Indeed, he stated with a certain pride that he based his data centre training on Crew Resource Management, a training framework that emphasizes the development of non-technical skills, such as communication, leadership, and decision-making, in order to optimize the integrated use of all available resources (people, equipment, and procedures), with the goal of ensuring the safety and efficiency of flight operations, extending beyond the cockpit to encompass the entire crew and the broader set of operations. Above all, this type of training seeks to reduce the risk of human error that can lead to serious consequences. He explained that the transition from aircraft to data centres was not abrupt, since in both contexts there is a latent tension to ensure that operations proceed smoothly and effectively. For this manager, a data centre is equivalent to an aircraft in flight and demands comparable readiness and preparation to deal with moments of crisis. This would not be the first metaphor I would hear describing data centres as something that requires an alert subject who strictly adheres to procedures.

There is, therefore, a certain rigidity in this setting—which is not a problem, since these are established modes of producing curricula and subjects, with their respective procedures and rituals of verification and accountability. The same cannot be said of the world of data centres. They are not exactly something *beyond* discipline, in the sense of Deleuze's (1992) notion of control, but they *exceed* the diagram established by SENAI as a disciplinary institution. If the players could casually state that the ideal worker is polyvalent across specialties—whose formation is incompatible with both SENAI's material resources and bureaucratic limits—it is because the data centre is a place whose productive regime pierces through the lines of worker-training rhythms and through the lines that structure curricular organization. As Carlos suggested, this results from the very rhythm of capitalist innovation, which periodically produces new technical languages, new standards, new forms of labor organization, making it difficult for people and institutions outside the market to keep updated. This disjunction will reappear in various iterations in the chapters that follow.

Chapter 4 - Energy

Prologue: Promises of Abundance

During the presentation of a photovoltaic energy company at a seminar on environmentally sustainable networks, its CEO listed different forms of green energy: tidal power, which converts ocean waves into electricity, is promising but still under development and remains expensive; geothermal energy, which uses water heated in aquifers, is quite clean, though it entails environmental impacts due to the depletion of groundwater; wind power, in turn, is polluting in terms of the noise it produces and its blades, which must be replaced and are difficult to recycle; finally, the most promising source, solar energy, for which the speaker mentions no environmental drawbacks.[14] Equally notable is the presentation of this energy source in relation to the celestial body that emits it—the Sun—as an "inexhaustible source." His claim recalls the heliocentric political economy outlined by Bataille (1988), in which he states that "[t]he origin and essence of our wealth are given in the radiation of the sun, which dispenses energy – wealth – without any return. The sun gives without ever receiving" (28).

If Bataille pointed to the Sun to make his argument, the players look to the entire Earth: rivers, wind, uranium—anything that can be turned into energy is out there for the taking. Such understandings of the Sun and Earth, although not entirely incorrect (albeit morally questionable in the case of the industry players), conceal in their simplicity ideas of value and ecological relations that are far more complex than an exuberant gift. Behind every abstraction—whether a metric of energy or of labor—there lies a process that generates

14 Power Usage Effectiveness is a metric that calculates the ratio between total energy consumption, including, for example, lighting and cooling, and the energy devoted to powering the core activities of data centers (servers and related equipment). The closer the PUE is to 1, the more efficient—and therefore more environmentally friendly—the data center

separation, destruction, and homogenization. Thus, the next section will show the numerical achievements Brazil has reached in terms of renewable energy, and then explore the price paid for them.

According to data from ANEEL (the National Electric Energy Agency), more than 84% of Brazilian electricity is produced from renewable sources. Of the total electrical production, 53% is generated by hydroelectric sources, divided between dam-based hydropower plants and run-of-river plants.[15] Indeed, Brazil has 2 of the 5 largest hydroelectric plants in the world, making the country a promising place for the consumption of this resource. Considering that the most sensitive (though not the only) process driving climate change is global warming caused by greenhouse gas emissions, the use of energy from renewable sources fuels a discourse of data centre environmental neutrality. This lexicon—composed of terms such as "neutral," "clean," and "renewable"—not only offers an ecological counterpoint to extractive and manufacturing industries long powered by carbon-based energy, but also proposes a future reduced to data and energy.

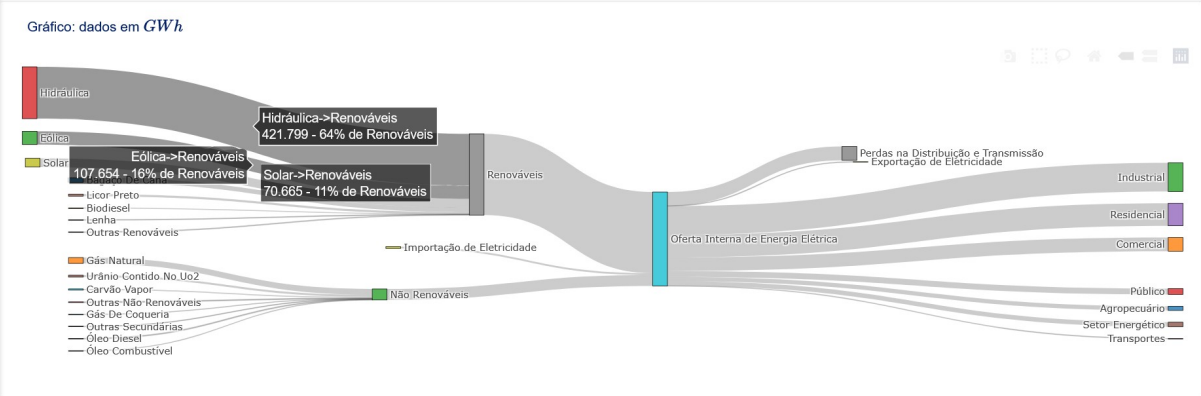


Figure 8. Brazil's electric energy matrix, showing the share of each generation source. Source: Empresa de Pesquisa Energética (EPE), "Electric Energy Matrix – Brazil," accessed August 23, 2025, https://dashboard.epe.gov.br/apps/ben/. The three main electricity sources, Hydropower, Wind, and Solar, together represent 91% of all renewables, or almost 600.000 GWh.

15 A Faraday cage follows the principle of a lightning rod, which "captures" electricity from a given point and distributes it across the surface.

If data centres are infrastructures "designed to continually mitigate interactions between natural and designed aspects of both technology and the environment" (Hogan 2021, 283), it is worth asking how these interactions become possible. More specifically, it is worth asking how energy became a fundamental element in transforming data centres into an infrastructure considered environmentally neutral. Beyond a sociotechnical understanding of what it means to make a river, the wind, or the Sun "work," it is important to situate historically some cases that made Brazil a model of abundant energy infrastructure, one perceived as less harmful than coal or petroleum. This chapter therefore traces a theoretical trajectory that explains how "nature" became a locus for the exploitation of labor. This process is never peaceful; it always involves destructive actions toward ecosystems and the people who inhabit them. Thus, this chapter analyzes the metrics that compose the ideas of energy and work. In doing so, it clarifies how the key element of a critical political economy—work—is hidden within the idea of clean energy. This work does not exist as an abstract entity; it is produced through coercion. As part of the march of progress, such coercion is exemplified in hydroelectric plants, which literally hide the violence of their genesis beneath the water.

Finally, the chapter returns to fieldwork experiences in which players—such as the solar-energy CEO mentioned above—articulate their own fantasies and desires for growth based on this "given" of clean and unlimited energy.

Work and energy: Metaphors we live by

The energy potential of power plants is measured in megawatts (MW). Watt is the unit that honors one of the main innovators of the steam engine, James Watt. It is used to measure the amount of energy, and in the scientific notation of physics, the watt measures the amount of work performed per second. Work, in turn, was conceptualized by Sadi Carnot, the French

physicist considered the founder of thermodynamics. In studying the steam engine, Carnot formalized the equivalence between heat and work through the conversion the engine performs between one and the other. And thus, substances are discovered, phenomena are captured and reproduced in abstractions and devices branded with the names of their authors. It goes without saying that this condensed history, with its logic of discovery of natural phenomena and almost immediate coupling to technoculture, possesses sufficient coherence for us to live our lives without major concerns. However, when one asks "what is" a given concept considered fundamental to our reality—such as energy, matter, or work—we realize that the stories of discoveries and the names of their discoverers are not only insufficient, but explain more about the social world of researchers of nature than about nature itself.

This question could be nothing more than an epistemological stubbornness if it had not appeared frequently in fieldwork. Actors from different data centre companies and related sectors mobilize ideas about energy and heat that treat them as a resource, a reservoir of value, or an opportunity cost to be exploited. One of my most receptive interlocutors welcomed me for the first time into his data centre by explaining basic concepts of physics, how this knowledge was used for his company's business, and how energy was a raw material to be treated and purified in his infrastructure. At an event on energy regulation for the data centre sector in Brazil, a head of operations stated that "energy is the most important input in the data centre sector, and this has several ramifications for Power Usage Efficiency in day-to-day operations." These understandings of energy as a substance or reservoir of value are not merely poetic licenses created by professional-managerial workers, but rather the legacy of scientific definitions that rely on metaphors grounded in aspects of the culture in which they gain consistency.

The idea of something that is part of the essence of a body or that produces life and movement has concerned Western thought since antiquity. For the scope of this thesis, what matters are the efforts to understand the concept of energy during the period of consolidation of modern capitalism. In this sense, it can be said that the concept of energy emerged from the steam engine both as an empirical object, part of relations of production for capital accumulation, and as an abstract machine that demanded a synthesis of heat and work for understanding its functioning. Indeed, when analyzing works dedicated to the conceptualization and understanding of energy between the eighteenth and twentieth centuries, Lopes Coelho (2024) argues that, to this day, there is no consensual definition of energy. Instead, Lopes Coelho argues that in different attempts at conceptualization, physicists and engineers relied on metaphors to make sense of the material dynamics between heat and work. One of these metaphors is that of capital as a reservoir of potential work. Employed by Max Planck, the German physicist, and by William Thomson and William Rankine, mathematical physicists and engineers from the United Kingdom, this metaphor expresses "the ability of a body to do work. This capacity of the body is analogous to capital, which by itself does not do commerce" (Lopes Coelho 2024, 95).

Energy as "capital" was part of an effort to reify energy, so that the concept would have a tangibility akin to other objects that compose the ontology of physics as a science. According to him, the most viable way to conceptualize energy is through the metaphor of substance. In this way, it can be taken as a thing whose form changes as it is transmitted across different materialities. However, citing Heinrich Hertz's *Principles of Mechanics* (1899), Coelho points out that such an understanding enters into contradiction with the existence of potential energy, since it can assume negative values. It follows that "[t]he difficulty with energy lies in the following: it is conceived as a substance when it contradicts the very concept of

substance. In conformity with Hertz's criteria of evaluating a physical theory, energetics is logically non-permissible" (Coelho 2024, 106).

If, under the scrutiny of a scientifically objective description, "capital" and "substance" form an unsatisfactory pair for a cohesive formalization of energy as a concept, these metaphors nonetheless help to discursively and technically constitute the productive social forces of the period. According to Mirowski (1989), they can be understood as an idea of energy as the axis of a pyramid whose base consists of the axes "body," "value," and "motion." From these axes, he analyzes the efforts of researchers from the same period addressed by Coelho, such as James Joule. In discussing Joule's work with his father's brewery, Mirowski argues that "[b]ecause brewing was already largely mechanized, Joule was not absorbed with the problem of animal heat or the mechanical equivalent of human labor, and thus there are few traces of the metaphor of the body in his work" (Mirowski 1989, 129). In this way, Joule "provides the important construction of one face of the pyramid, the one that is bounded by energy, motion, and economic value" (128).

The relationship between body, motion, and energy, in turn, made it possible for materials of distinct natures—human, machine, and animal—to be abstracted through their capacity to produce work. The precursor of this process, the German physicist Julius von Mayer, "was a man with a single idea, and that idea was the qualitative reduction of organic phenomena to inanimate physics, in order to dispel the 'inscrutable' and 'hypothetical' character of vital forces" (Mirowski 1989, 39). It is important to emphasize that this is not about attributing individual agency to supposed genius or individual endeavor, but rather about showing that individuals such as Mayer and Joule, even as they were invested in their studies and inventions, were part of broader transformations in the production of technologies and knowledge that transformed human and non-human nature into a capacity to produce work.

Or, in the words of Anson Rabinbach (1991), when addressing the social changes brought about by the steam engine: “the body appeared as a field of forces, energies, and labor power. The metaphor of the machine underwent a change from that of a clockwork composed of diverse parts to that of modern motor modeled on a steam engine or electric-powered technology” (66). This interplay of metaphors—making energy a potential for work within matter, whether animal, vegetal, or mineral, and the machine a means to liberate and order it —was fundamental to the understanding of nature as a commodity.

Therefore, more than scientific trivia, this collection of names, measures, and facts demonstrates that between the eighteenth and nineteenth centuries there was an intensive effort to formalize and materialize concepts about how nature operates. This effort, however, was not merely scientific curiosity about nature and the mechanisms accelerating the transformations of modernity. As Stengers and Didier (2005) argue, it was part of the concomitant histories of the normalization of social conduct and the normalization of nature and its phenomena. Thus, if Carnot, Watt, Joule, and many others “sought to show how a law gets the power to give its meaning and its reason to technique and how, by way of this law, an operation of measurement is transformed into an internal norm of phenomena” (391), people such as Frederik Taylor sought to dominate the worker’s body not through the brute force of slavery but through scientific management, measuring their times and movements and elaborating norms to discipline them and extract value.

The desire to maximize production through technology as a means of exploiting nature was a common theme among these engineers and scientists. James Joule, for example, believed that “[i]f the power of the engine is in proportion to the attractive force of the magnets (…) the economy will be in the direct ratio of the quantity of electricity and the cost of working the engine may be reduced ad infinitum” (1842, 334). This belief, even though later abandoned

by Joule himself, marks the modern-capitalist drive to obtain energy in exchange for nothing, or almost nothing, such that a hydroelectric plant is just one example among other ambitions, such as nuclear plants.

The advent of the hydroelectric plant represents another stage in a sociotechnical process based on absorbing nature into infrastructures to extract value from it. In other words, water, by passing through the turbine and causing it to spin, begins to "work," and how much the turbine spins per second results in the value measured in watts. Thus, the application of force —whether from a water current, the traction of a horse, or the movement of a human arm— are all examples of transferring energy from one point to another. In rivers, in the atmosphere, and from the Sun, this energy transfer occurs, respectively, through the friction of H_2O molecules, of O_2 and N_2 molecules, and through the radiation of solar rays. Wind and river flow arise from molecular interactions resulting from transferred and dissipated energies such as those just mentioned, as well as forces like gravity. This composition of forces, in terms of matter and energy, conditions the modes of existence of living beings, including humans. That is, the kinetic movement exerted by these natural elements (work as conceptualized by physicians such as Joule) demands conscious forms of transforming these elements not only to survive these energetic processes, but also to appropriate them as part of human subsistence through labor.

The process of occupying the American continent and the efforts of the invading peoples to survive and prosper is useful for understanding the interplay between human labor and non-human work. The case of the Columbia River, according to Richard White (1996), illustrates how the energetic relations between nature and culture affect one another: As a means of navigation, the river's kinetic energy was a threat settlers needed to overcome. For the Chinook and Clatsop peoples, the river harbored energy in the form of calories contained in

salmon. For the American and Canadian governments of the twentieth century, the river was treated as a potential source of electrical power. Between a source of subsistence and a key infrastructural component, White's work shows how the Columbia River was reworked by the people who depended on it, through the different technologies used to control and extract its different forms of energy. More than a case of cultural relativism—in which different peoples simply ascribe meaning to an external reality—rivers and humans mutually transform each other's potential for agency.

White's study is relevant because it shows that different energy gradients in nature require specific forms of technique and technology in order to be domesticated. The Columbia River posed a challenge to Europeans, who benefited from using boats made by Indigenous peoples. The effectiveness of Indigenous canoes depended both on their design and on the embodied way of using them in accordance with the river's force. Technique, therefore, is not merely the externalization of a plan or idea; it is the (re)production of a body and the performance of procedures through it, based on a given set of forces, in order to achieve an expected result, whether collecting a certain amount of fish or moving from one place to another with the help of water or wind.

If an energetic composition shapes a particular sociotechnical configuration, the reverse is also true. A society that conceives of humanity as separate from other beings understands a forest or a river as things to be manipulated—objects for extraction and for taxonomic and quantitative understanding. Just as important as the Enlightenment project that underpins modernity is the capitalist mode of production. Thus, a capitalist and industrialized society is more inclined to see the river as a potential source of value. This value may be extracted by mechanizing salmon fishing, first turning fish into a commodity, or by viewing the kinetic energy of water itself as a source of electricity, as was the case with the Columbia River.

Thus, between an Indigenous canoe and a North American hydroelectric plant lies a difference in worldview and scale. Worldviews should not be confused with ideology or discourse, where meanings are interchangeable representations of a hard truth indifferent to human existence. They constitute an understanding of the cosmos that carries ideas of personhood and material and bodily possibilities among humans and non-humans. For the peoples who lived there before European arrival, the Columbia River was not merely a place with water and fish but a sacred part of the mythology explaining their origin, and part of their bodies, which placed them in interspecific relation with salmon. The same cannot be said of contemporary societies living under modern precepts. This is because instrumental reason and technoscientific development frame the world as a space to be understood through the quantification of variables and their refinement into data. More than a conceptual formalization of the world, this shift involves a material reconfiguration of how nature is managed; it marks a turning point in ways of acting in the world—namely, the transition from technique to technology. This shift not only increases the magnitude of impact that this type of human intervention has on nature, but also alters the topology of the nature–culture divide in terms of relations with the environment.

This shift becomes clearer when comparing the mediations afforded by technique versus technology. Take, for example, a river mill and a hydroelectric plant: at first glance, both appear to follow a similar logic, differing only in scale and in how the river's energy is transferred and transformed. However, the mill, like the canoe, is a whole whose production and maintenance can be understood without great specialization. Its component parts and the labor required to build it can be mastered by an individual or a small group. Moreover, the mill depends on the downstream flow of the river to capture its energy, so the river encompasses the mill. The river conditions the mill's engineering, and this condition demands corporeal proximity between the individuals involved and the artifact. Technique is

precisely the relation between body and matter within the environmental limits in which it is performed: always maintaining, of course, the modern cleavage between nature and culture.

A hydroelectric plant, in turn, could be understood as following the same logic as a mill by simply capturing more kinetic energy from the river. However, it is more than a quantitative increment; it effectively takes over the river, becoming what Lewis Mumford (1967) calls a megamachine. According to Mumford, this type of machine, historically preceding the steam engine, consists of the chain of command that a centralized authority, such as a king, was able to mobilize. This command chain enabled the division of labor and the transmission of orders needed to build, for example, a pyramid. Mumford's definition is valuable because it suggests that machines are not merely material arrangements of levers and pistons; they are sociotechnical compositions not bound to a linear technoscientific progress but conditioned by the political and cultural elements of a society.

As an example of technology, a megamachine such as a hydroelectric plant demands a hierarchy and a specialization that alienate the individual from any holistic functional knowledge. This division of labor, in turn, allows for greater reach and impact on the type of resource to be extracted and distributed. However, the consequences go beyond logistical expansion: hydroelectric plants (particularly those requiring dams) absorb the river, deforming it and making it part of themselves. This specific way of putting nature to work implies the very implosion of the nature–culture divide, since the river comes to exist in function of the infrastructure, just as the infrastructure requires the river to justify its existence.

Thus, one may interpret this new environment not as nature, nor solely as infrastructure, but as what Swyngedouw (2007) calls technonature. More than a clever terminological fusion, the term helped him analyze the making of Spain's hydroelectric system as a process in

which “symbolic formations are forged, social groups enrolled, and natural processes and ‘things’ entangled and maintained” (10). The different vectors of political power, nation-building projects, and environmental elements of a territory are parameters that help situate historically how nature was re-signified and assimilated by technology.

This theoretical trajectory shows how the specific sociotechnical agency of modernity, by presuming nature to be a non-human topos ready to be exploited, ultimately results in the practical and conceptual absorption of nature by technology. Such absorption is nothing more than a component of capitalist relations of production. This absorption, in its turn, depended on machines whose functioning depended on translating nature into quantifiable concepts, like work and energy. Being machines functioning under the capitalist mode of production, work, energy, and the being producing them are converted into commodities. Thus, the possibility of something being measured in joules, watts, or dollars denotes a dual submission: to modernity’s project of domination over what it considers non-human, and to the logic of capital accumulation and reproduction.

The development of machinery that measures nature and converts it into energy, labor, and value constitutes the technological basis that mediates between the modern subject and nonhuman nature. Its operation is based on reducing the complexity of ecosystems to energy, whether in its current, active form or as potential energy stored in reservoirs. The production of such reservoirs is not implemented smoothly or peacefully, but entails acts of violence against ecosystems and those who live within them. The next section presents historical cases of how two Brazilian rivers underwent this process.

Itaipu

Construction of the Itaipu Binational Hydroelectric Power Plant began in 1973, during the military dictatorship (1964–1985), and at the time it aimed to be the largest hydroelectric plant in the world. Located in the Paraná River basin, the project arose from a collaboration between the Brazilian federal government and the Paraguayan dictatorship, supplying both countries with electricity. It consists of a flooded area of 1,350 km² feeding 20 generating units (turbines that convert kinetic energy into electricity), producing a total of 14,000 GW of electric power, half of which goes to each country.

It is important to briefly outline the Brazilian political context of the time. The country was experiencing the most violent period of the dictatorship, marked by the consolidation of Institutional Act No. 5, which severely restricted individual rights and intensified the persecution of political dissidents as well as citizens with no political ties. The year 1973 was also an economic and energy milestone for Brazil: the oil crisis erupted that year, prompting the country to develop energy-production programs independent of oil, such as Proálcool; it was also the end of the so-called “economic miracle,” a period in which the State invested heavily in public companies focused on infrastructure and heavy industry. This investment was supported by an economic strategy and an ideological component. The former refers to an import-substitution policy that promoted manufacturing industries to supply domestic demand. The latter concerns the military rulers’ ambition to position the country as a regional economic power.

Indeed, the Itaipu power plant embodies this double dynamic. Its monumental scale not only symbolized the regime’s supposed vigor in carrying out a territorial-occupation project but would also become the main enabler of Brazil’s subsequent economic modernization. At the time, Brazil was undergoing rapid urbanization and industrialization, with the population

increasingly consuming household appliances and the international division of labor making the country a promising manufacturing hub, particularly for the automobile industry. This success, however, did not occur peacefully, nor were its benefits evenly distributed. The dictatorship was marked by the State's arbitrary use of violence to maintain power, and by institutional and political support for capital interests. It is in this context that we can briefly examine how the Itaipu plant, today the third largest in the world, submerges histories of violence and injustice in exchange for clean energy, now considered central to energy transition narratives.

For a large-scale project to come into being, a given territory must be designated as *terra nullius*. This colonial fiction only becomes reality through the coercion that expels its original inhabitants. The first group affected by the construction of Itaipu were the land's original inhabitants, the Oco'y Guarani Indigenous people. Although displacement and violence obviously date back to the arrival of Europeans, the process of deterritorialization they underwent took on new forms under the dictatorship. According to Carvalho (2013), "INCRA and even FUNAI tried to strip the subjects of their territorial rights by classifying them as 'non-Indians'; IBDF/IBAMA, INCRA, and ITAIPU drastically reduced the extent of the territory legally guaranteed to them; and finally, all of these government institutions distorted the facts (…) in order to avoid compensating them with land as required by law" (67). Thus, the State, through institutions created ostensibly to protect Indigenous people and support agrarian reform, deployed various legal and illegal measures to alienate the Guarani from their territory and even from their legal recognition as Indigenous.

It is important to situate the construction of Itaipu within a broader context of Indigenous extermination during the military regime. As noted earlier, the State used both legal and illegal instruments to persecute political opponents and repress the population at large, no

different were its actions toward Indigenous peoples. Indeed, relations between State institutions and Indigenous populations, from colonial times to the present, have been conditioned by territorial control and value extraction through the erasure—physical, legal, or cultural—of these peoples. The dictatorship intensified this process, weaponizing institutions that supposedly existed to protect Indigenous communities. As reported in prosecutor Jader Figueiredo Correia's 1967 investigation, officials of the Indian Protection Service (SPI, later FUNAI) systematically subjected Indigenous groups to humiliation and violence, including torture, deliberate infection with smallpox, slavery, rape, murder, and land theft—echoing the accounts collected by Michael Taussig (1986) about rubber extraction in the Spanish Amazon.[16]

The second group affected were the fishing-and-farming communities living along the Paraná River. Ulloa Campos (2006) shows how the construction of the plant played a central role in expelling these communities, flooding fertile land and disrupting the local ecosystem. Despite the promises of economic development arising from the project, the incipient urbanization of the areas that received displaced families did not lead to the formation of a local economy, and the expected benefits of the infrastructure project never materialized. Moreover, attempts at historical reparation and local development were unsuccessful.

If on one hand Brazilian capital and the country's nascent industrial sector are indebted to Itaipu, on the other hand the construction of the plant brought harmful economic consequences for the Brazilian State. One well-known, though not exclusive, feature of large-scale state projects is cost escalation relative to initial investment expectations. In the case of Itaipu, costs rose from USD 3.6 billion (Campos 2006) to USD 27 billion. Part of these

16 The "immaculate conception" of data is not a hyperbole, but a way to show, in a single stroke, how data objectivity is embedded in values external to the techno-scientific sphere, and to underline that the process of abstraction that renders them supposedly neutral signs of reality demands a sometimes dogmatic belief. As Bronson (2022) notes with respect to agricultural production: "just as religious doctrine makes pure the conception of a fetus, ICD performs an abstracting function for purportedly data-driven food production by promising its separation from the human–material interface" (97).

additional costs, as often happens in engineering projects, stemmed from circumstantial changes, logistical setbacks, inflation in labor and materials, and other variables. However, Victorio Davalos (2009) demonstrates that a substantial portion of the increase came from interest payments, since “higher costs meant larger investments and larger contracts for companies and, of course, greater indebtedness and benefits for financing entities” (172). The accumulation of interest generated a debt that, in 2006, was nearly twice the amount of direct investment made in 1997 (180). Thus, one could say that the plant effectively became a generator of interest payments owed to its creditors, influencing electricity prices and limiting future investment capacity. This situation only ended in 2023, when the debt was finally paid off.

Belo Monte

Currently the second-largest hydroelectric plant in Brazil, the Belo Monte Dam has a problematic origin and catastrophic socio-environmental outcomes. Conceived and with its technical feasibility studies initiated during the dictatorship, and later built in the post-dictatorship context, it is located in the Amazon Basin and its dam interrupts the flow of the Xingu River. Its flooded area spans 478 km², and its installed capacity is 11,233 MW. Construction was relatively fast, beginning in 2011 and ending in 2019. Belo Monte has local and historical specificities that require an approach that goes beyond the dam itself. For this reason, any analysis of Belo Monte must be articulated with another nearby infrastructure: the Trans-Amazonian Highway. The aim is to show how infrastructures produced under opposite political regimes nonetheless share the same project of domination over nature.

The case of Belo Monte is emblematic due to the dilemmas embedded in its design and construction. Unlike Itaipu, the area where Belo Monte was built is located within a biome as

fragile as it is diverse: the Amazon. It is also important to note that the Amazon region—beyond being labeled (albeit technically incorrectly) the "lungs of the world"—plays a fundamental role in maintaining climate patterns across the subcontinent. The region is traditionally inhabited by Indigenous groups such as the Arara, Juruna, Kuruaya, and Xipaya, and later by the Kayapó, who were expelled from central-western Brazil due to agricultural expansion (Simoni and Dagnino 2016). Another demographic component is the *ribeirinhos*, descendants of rubber tappers who migrated to the region in the 19th century.

Within this social and ecological context, Altamira (the city that received the investment for Belo Monte) offers a significant microcosm of the broader Amazonian region as a decisive site for national development projects. Each successive government has advanced a particular project of economic exploitation in the region, which entails specific modes of territorial occupation. The relation between economic cycles and population dynamics is evident in sharp demographic swings: according to Simoni and Dagnino (2016), between 1920 and 1940, the end of the first rubber boom, the city lost almost 3,000 inhabitants. Between 1960 and 1970, the beginning of construction of the Trans-Amazonian Highway, the population more than quadrupled, rising from 5,905 to 26,905. Between 2000 and 2010, the decade when Belo Monte was built, the population grew by nearly 28,000. The intensity of this growth reflects the State's push to view the region as a space for intense exploitation. Far from major urban centres, Altamira required a route that enabled the flow of people and goods. In practice, despite official developmental rhetoric, the Trans-Amazonian Highway facilitated illegal logging and mineral extraction, expanding environmental degradation and violence against Indigenous peoples.

The state-led expansion of infrastructure across Brazilian territory can be understood as one of several attempts to exercise sovereignty over a vast land. This sovereignty aims to

transform this perceived civilizational void (*terra nullius*) into progress. While *terra nullius* is a fiction constructed through genocide and environmental destruction, it is presented by capital and the state as a space of economic potential to be exploited. If in the dictatorship this space represented a mission of sovereignty to be fulfilled by the army, in the democratic government of the 21st century *terra nullius* became attractive to market actors eager to transform non-human nature into energy through governmental developmentalist policies. These policies faced bottlenecks that became evident after major blackouts in the 2000s, signaling a limit to the consumption levels of the emerging middle class. That limit manifested in rising electricity prices, affecting both urban residential consumers and the productive sector. Increasing energy costs became the government's primary argument for building the dam, framing the debate as a dichotomy pitting purchasing power and development against environmental and Indigenous concerns.

Unlike in the case of Itaipu, where dialogue with civil society and with those directly affected by the flooding was virtually nonexistent, the democratic regime allowed debates on Belo Monte's technical, financial, and socio-environmental feasibility. These debates were punctuated by moments such as the now-iconic meeting between Eletronorte officials and Kayapó representatives, when the leader Tuíre Kayapó threatened the president of Eletronorte with her machete. Such episodes make clear the actors (or *stakeholders*, from the perspective of companies such as Eletronorte's) involved in the conflict unfolding on the Xingu River. At one level, this dispute concerns the central issue of this section: the dilemma between national development and environmental preservation. At another level, the dispute lies in the power struggles that define how the problem is framed. From the government's perspective, for instance, "instead of discussing the local impacts of the dam, government reports and publications focus on the national impact of increased energy generation" (Gilbert 2016, 67).

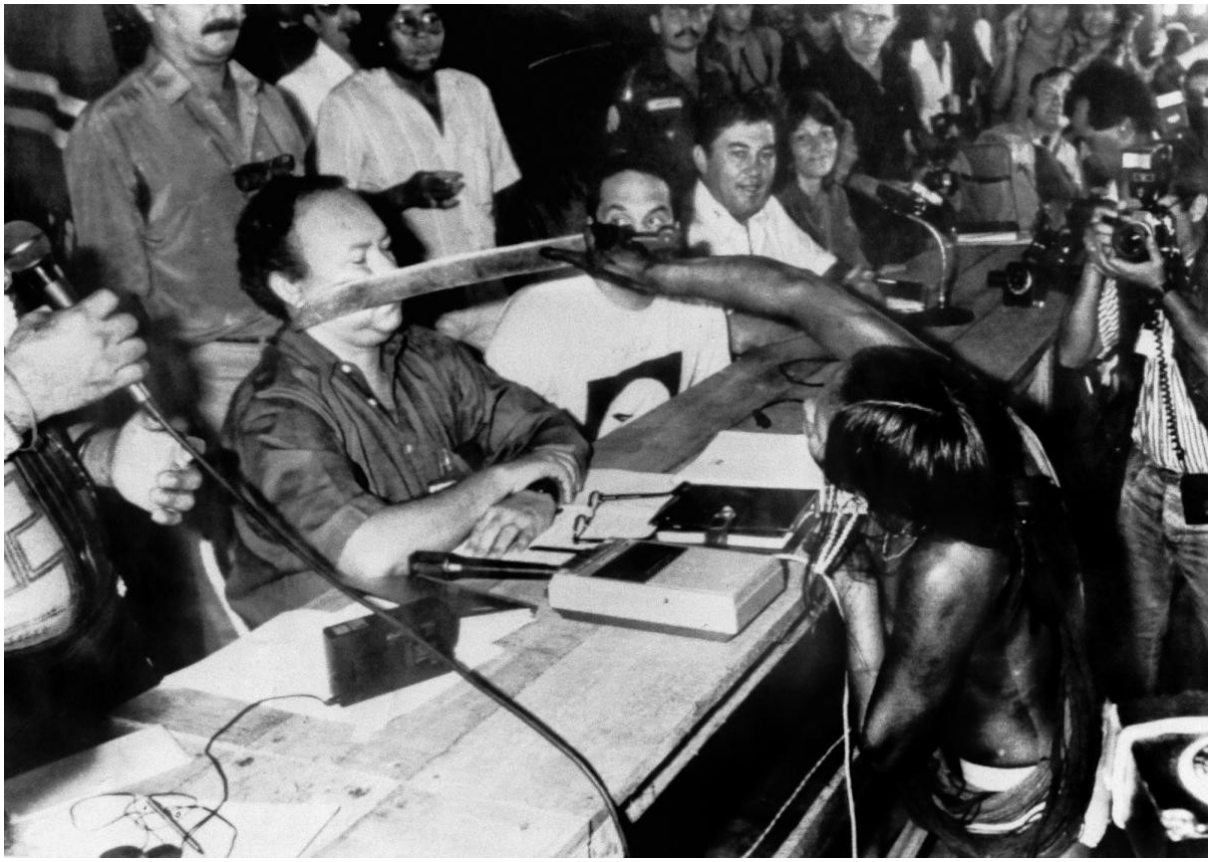


Figure 9**.** Tuíre Kayapó doing politics with Eletronorte's president. Source: Instituto Socioambiental (ISA), accessed September 16, 2025, https://www.socioambiental.org/sites/default/files/styles/large/public/2024-08/RS140487_154601_Final_30x20_lpr.jpg?itok=ERrMtbCP.

As already noted, the Belo Monte Dam is located in the Amazon River Basin, in the northwest of the state of Pará, with Manaus in the state of Amazonas being the nearest urban-industrial centre, more than 2,000 km away by car. It is also close to the Trans-Amazonian Highway, a relevant fact for understanding the historical ruptures and continuities produced by infrastructures undergoing processes of decay. This highway, built during the military dictatorship, was intended to serve as a vector of occupation for the northern region, enabling the colonization of the Amazon and functioning as a logistical axis for urban and agrarian development projects, while also connecting the region to Peru and Ecuador. It is important to remember that the dominant military discourse at the time framed the task as confronting the so-called "green hell"—that is, fetishizing the Amazon as a wild, hostile place

incompatible with human life (meaning: modern life), such that the government's civilizing mission justified the violence inflicted upon the peoples living along the highway's path.

In the end, its construction was a failure, and the Trans-Amazonian became known as a road that "connects nothing to nowhere." The decrepitude of an infrastructure is a sign of "imperial debris" (Stoler 2008), even when the production of that ruin is endogenous to the territory and its people. This marker, however, is not limited to the highway itself but pertains to the broader imaginary of *terra nullius* that emerged with the arrival of the Portuguese and has been updated with each new political regime. In other words, the Trans-Amazonian is simultaneously the means and the material proof of an imagery that reduces Indigenous peoples to conditions of inferiority (or to beings without souls, or to animals—depending on the historical moment), of a necropolitics that attempted to annihilate them, and of the transformation of a complex biome into quantifiable commodities, especially in the form of exchange value. Even though it was never completed, the highway remains in use in its operable stretches, and just as this infrastructure persists, so too persist the forms of violence and extraction exerted upon peoples and territories positioned at the frontiers of capitalist expansion—even if they now occur under institutional scrutiny.

Indeed, it is at the "President's Stick," the name locals give to the highway's initial marker, that the city most gravely affected by Belo Monte is located. This is Altamira, which saw its population double during the dam's construction years. The abrupt population increase, however, was not accompanied by adequate investment or infrastructure, and the city became a vast pocket of poverty and violence. Today, it is a battlefield between criminal factions fighting for control of drug trafficking, and landowners who employ private security forces to coerce and murder Indigenous people and landless workers. The case of Altamira shows that mega-projects with deep environmental impacts do not merely displace populations living in

the affected territory; they also transform social dynamics in communities already marginalized by the state, fueling competition among different factions of organized crime and intensifying regional violence.

The completion of a hydroelectric dam can be understood from various angles. These structures can be seen as monuments that mark a kind of living death for the lives submerged in the flooded area, but even more so for those who are displaced or abandoned by such projects. The rupture of family and neighborhood ties and the loss of connection to the land amount to anomic living death. As Gilbert (2016) suggests, even a center-left government in a democratic state is unable to propose a model of economic development capable of effectively securing the right to exist for non-capitalist, non-modern forms of existence.

Needless to say, if one were to rely solely on the perspectives of my interlocutors, the discourses delivered by industry players at events, and ESG reports, the histories of Itaipu and Belo Monte would not be a topic of this thesis. This is not to suggest an insensitivity on the part of my interlocutors toward environmental and social issues, nor to make the somewhat obvious denunciation of data centre companies' lack of interest in these matters. Rather, one may speculate whether the process of economization, as proposed by Çalışkan and Callon (2009; 2010) and employed in the analysis of ESG reports, begins precisely with the coupling of nonhuman nature to infrastructures of extraction.

In other words, if they coined the term "to denote the processes through which behaviours, organizations, institutions and, more generally, objects are constituted as being 'economic'" (Çalışkan and Callon 2010, 2), one might add that a hydroelectric plant, insofar as it is a technonature in the sense proposed by Swyngedouw (2007), is constituted by processes that render it a being economic as well. In this sense, it is pertinent to add that processes of

economization, insofar as they take place within a regime of capital accumulation, involve modes of violence that adjust human and nonhuman natures to the commodity form.

Energy: Its uses and prices

It is through the sign of this commodity called energy that I established my contact with some of my interlocutors. It goes without saying that the history behind the energy they purchase and consume is irrelevant to them; what matters is only how it can be used as efficiently as possible in the present, so that it can be consumed in greater quantities in the future. Before examining the details of this contemporary iteration of the Jevons paradox, however, I first explore how electrical energy is handled within data centre environments.

The first case to be examined is that of the second company that received me, Peekaboo Telecom. Carlos, its CEO, took me on a long guided tour, presenting various techniques he and his business partner developed that comprise the electrical and climate-control infrastructure of the data centre. One specificity of this company, as its name suggests, is that it is also a telecommunications firm, providing internet services and functioning as an Internet Exchange Point, which is what initially led me to contact them, as described in the previous chapter. The presentation of Peekaboo Telecom's data centre and that of Unicorn Data Centres will be divided according to the topics of this chapter: this section emphasizes energy; the next, information; and finally, computation qua environment.

The handling of electrical energy was explained in detail by Carlos. One of the first definitions he offered of his company is that it purchases electricity wholesale and sells it retail. With this, he contrasts larger companies with his own medium-scale edge provider, focusing on clients who need a single rack or less, such as small businesses or consulting offices (the "crumbs" ignored by the big players). Since this involves reselling energy to

smaller clients, I asked how this intermediation works. He explained that this is done through the *Mercado Livre de Energia* (Free Energy Market), a trading environment where consumers (especially companies) can choose and contract electricity suppliers directly, freely negotiating conditions such as price, quantity, and duration. In this way, one can establish purchase contracts with flexibility, cost-saving potential, and the option to choose renewable energy suppliers. This allows pricing to be planned for client contracts, as well as expected profit margins.

To return once again to Çalışkan and Callon, what is subjected to economization begins with the dammed river, as outlined in earlier sections of this chapter. But it is not only the river in its condition as part of a dam; it is also the labor it performs by turning the turbine. The transformation of kinetic energy (joule) into electrical energy (watt) is guaranteed by the employees of the hydroelectric company, who perform maintenance, administration, and other tasks. It is therefore a process of transforming the river into kinetic labor, electrical energy, and commodity, such that none can be thought without the others. After passing through transmission towers, usually crossing thousands of kilometers, the electricity reaches the buyer. The attentive reader will notice that I refer to "the river" generically, unlike the careful situating of the two emblematic cases earlier in the chapter. This is no oversight, but an emphasis on my interlocutors' view that the specific river from which energy is produced is irrelevant; what matters is the price offered by the utility that exploits its labor. Thus, price becomes the mediating sign between the source of electrical energy and the subject who consumes it.

The description of the economization process becomes denser as Carlos explains how electricity is treated upon arriving at the infrastructure of his data centre. By asserting that the data centre business is fundamentally an energy business, he claimed that energy costs

represent approximately 60% or more of a data centre's operating expenses, making efficient management paramount. When comparing Peekaboo Telecom with other data centre companies, Carlos argued that competitors often bill energy based on the maximum power capacity of the equipment's source (nameplate rating), forcing clients to pay for power they do not use. By offering real-time consumption data, his company allows clients to contract and pay only for the energy they actually consume, preventing the data centre from achieving "statistical gain" on unused power. This explanation is interesting because it invites scrutiny of the numbers displayed in ESG reports. Implicit in Carlos's comparison is that other companies might charge clients for wasted energy, as if it were being used by servers. Yet ESG reports show only the amount of electricity consumed.

Beyond this granular look at energy handling, Carlos explained in detail how electricity is treated upon arrival at his data centre. Unlike domestic consumption, where current reaches household infrastructure ready for use, electricity in data centres is "purified." This is because, according to Carlos, energy arrives "dirty" from the street — that is, with undesirable variations in voltage, frequency, waveform, and electromagnetic field. These variations occur because transmission lines are exposed to weather events such as lightning and to electromagnetic induction from other lines, causing, for example, sags, surges, and flickers. If electronic equipment were powered in this state, it would risk burning power supplies, carbonizing motherboard traces, shutting down servers, and freezing routers. If these consequences are undesirable for home equipment, they are unacceptable for companies whose raison d'être is precisely to ensure the uninterrupted operation of such devices.

With this in mind, Carlos deepens his explanation of how electricity is treated. The facility uses transformers (each with 1.8 MW capacity) to reduce the voltage from 13,800 V to 380 V (three phases of 220 V) for internal distribution. Transformers are used to increase or

decrease voltage via electromagnetic induction and operate according to the ratio between their coils. After this conversion, electricity still contains undesirable voltage variations, electromagnetic noise, and harmonic distortions from the public grid; therefore, it passes through UPS systems (no-breaks), which stabilize the sine wave, filter surges and dips, and ensure continuity in case of utility failure. Complementarily, surge protection devices (SPDs) divert abrupt overvoltages, such as lightning strikes, switching operations, or short circuits, to grounding, preventing their propagation to the racks. In this way, energy is progressively "cleaned" and conditioned along the chain that runs from hydroelectric generation to the A/B circuits feeding the servers.

Thus, the sequencing of these different devices, the care in handling (both to preserve equipment and protect operators), and the cabling systems that form a hybrid analogous to a nervous and circulatory system constitute a sociotechnical assemblage that is not primarily based on the exploitation of human labor. By this, I do not mean that Carlos shares profits with his employees, nor that their surplus labor is not appropriated. I mean that, compared with pre-robotic manufacturing paradigms in which most capitalist accumulation depended on enclosing the proletariat to extract surplus value, in data centres like Peekaboo Telecom and Unicorn Data Centres the revenue obtained derives from what is produced *on top of* this labor. This raises questions about the very nature of the value produced in such places. Caffentzis (2013), for example, argues that if most value production is carried out by machines, then the rate of surplus value — necessarily produced by humans — is lower, resulting in difficulties for capital accumulation. Less rigorously, and attempting to engage Caffentzis's hypothesis in a setting that apparently was experiencing robust growth, and thus capital accumulation, I asked Carlos how he generated profit in this context. He found the question silly and replied that he had already been answering it when describing energy and

climate handling. In other words, he, his handful of employees, and his army of machines are responsible for transforming clean energy into (surplus) value.

Anxious Growth

One of my final field experiences was attending a meeting organized by ABDC, featuring three panels on the challenges facing the sector's growth from an energy standpoint. It took place in the afternoon in a theater adapted for the event, and all 200 seats were occupied. Unlike the SENAI working group, where the atmosphere was marked by concern and introspection about the labor force they lacked, this meeting was defined by an optimistic anxiety. One after another, the invited speakers reiterated that the past few years had seen consistent growth and that, with AI, things would only improve. AI, however, has a new appetite for energy, and Brazil, they argued, is not prepared to satisfy this hunger.

Symptomatic of this sentiment was the diagnosis offered by one of the panelists. He mentioned recent annual growth rates of 10 to 15% in the sector, which he described as good indicators. But good was not enough — he wanted excellent indicators. And excellence, in his view, would no longer be a matter of fractional increases over a base value, but exponential expansion.

This feeling was reinforced by another panelist, the Latam Head of an infrastructure company. Commenting on the announcement of a set of measures meant to accelerate data centre growth in Brazil (the Special Tax Regime for Data Centre Services — Redata), he explained that he expected the implementation of this regime — which, among other effects, would reduce import taxes on GPUs — to take effect one week after being announced. As of his complaint, 45 days after the announcement (and still at the time of this writing, in late 2025), the measure had not been approved. This led him to conclude that the speed of the

sector's actors (especially government regulators) was good, but still not at the correct value. And what would the correct value be? For the previous panelist, it is the one that enables exponential growth.

The second panel was somewhat shocking for this researcher. It included representatives from wind energy companies, manufacturers of electrical distribution equipment, and a nuclear energy specialist. Nuclear energy was not entirely unfamiliar to me, since recent news had reported projects for mini nuclear plants meant to handle AI's energy demand. As noted in the previous chapter, this was also mentioned by my interlocutor at DCD Connect. Still, given the stigma and social pressure in the not-so-distant past for abandoning nuclear energy, this rapprochement struck me as absurd — especially in a country that prides itself on natural resources and infrastructural achievements in energy production.

The panel opened with the nuclear specialist. He began with a somewhat poetic remark whose implications merit exploration. According to him, the fields of data centres and nuclear energy had always been two parallel lines, each following its own trajectory, never intersecting — until, he claimed, they finally did. The pragmatic reasons for this convergence lie in new architectures for nuclear plants, making them less massive, less expensive, and more secure. As expected, he supports the use of nuclear energy, but not in the form of large plants with large-scale risks. Instead, he promoted the Small Modular Reactor (SMR) as an advantageous alternative for the Brazilian context. Smaller units, he argued, have lower upfront costs, shorter payback periods, and significantly enhanced safety. Moreover, the energy consumption profile of a data centre is practically flat, which is ideal for the continuous and reliable operation of nuclear power. Above all, SMRs open the possibility for distributed nuclear generation and nuclear self-production. This enables the creation of

weakly interconnected “local grids,” which he argued are crucial for the effective expansion of Artificial Intelligence.

Curiously, in the panelist’s view, the problems facing SMRs are not specific risks inherent to this type of nuclear plant, but rather the lack of government regulation for the sector, once again echoing the tone of the event as a whole. As his peers emphasized, he claimed that Brazil faces a unique growth opportunity, and decisions must be made as soon as possible, lest countries with similar potential move ahead. Few details were offered regarding the handling and disposal of radioactive waste, and nothing was said about security risks, whether related to possible accidents involving this type of reactor or to human factors. Because the event was running behind schedule (one of the ironies of data centre culture, where companies revolve around “mission critical” thinking and constant preparedness, yet coffee breaks of fifteen minutes easily extend beyond half an hour) questions to this panelist were not allowed. I certainly had several.

Before proceeding to the next figure and their stance on energy, I would like to expand on the imagery evoked both by the Latam Head with his desire for exponential growth and by the nuclear energy specialist with his parallel lines. When the latter noted that, at a certain point, parallel lines intersect, he did not mention that in projective geometry parallel lines meet at infinity. In painting, the vanishing point is the hypothetical place of this meeting. The Latam Head’s remark, for his part, shaped his peers’ expectations with the image of exponential growth, an image reiterated by the nuclear proponent, who conditioned nuclear energy’s environmental “friendliness” on enabling such growth. At first glance, proposing exponential rather than horizontal growth seems like a merely quantitative shift — a difference in numerical values. But sustained exponential growth has at its “limit” exactly what, in integral calculus, is called a limit: a vertical line that always approaches the y-axis of a Cartesian

plane but never reaches it. Between exponential growth and parallel lines, the two panelists produce an abstract image of data centres generating intelligence-value through the consumption of clean energy, whose vanishing point is the proliferation of power plants and data centres.

For Brian Rotman (1987), the vanishing point is a sign with a dual semiotic character. In a painting, it is a sign among others, such as the horizon or an architectural element. But it also "is in a meta-linguistic relation to these signs, since its function is to organise them into a coherent unified image" (19). The panelists are not painters, but they offer discursive brushstrokes on an image of progress that invokes infinity as desire and potential. As economic actors, this is the infinity of capital accumulation. Ironically, it is precisely this infinity that motivates economic actors to adopt so-called renewable energy sources. In other words, the images they assemble, invoking lines, processes, and futures, are themselves contradictory.

Part of this contradiction surfaced in a comment posted by one of my interlocutors on his LinkedIn account. In the second half of 2025, Brazil experienced an unusual crisis: solar and wind generation networks were producing more energy than was being consumed, creating an excess that threatened their operation. Curtailment measures became necessary and, paradoxically, thermoelectric plants had to be activated to supply energy during moments when these renewable sources could not be generated. One suggestion made by my interlocutor was to stimulate the consumer market for this energy, both to take advantage of what was being generated and to ensure the profitability of this infrastructure. Beyond the relevant infrastructural and governmental issues (one panelist, for instance, mentioned delays in government authorization of energy-purchase contracts for projects of data centre scale), there is anxiety both about expanding energy capacity and about ensuring energy is

consumed. The flow of matter, energy, and information occurring outside the capitalist circuit is treated as an error to be corrected, and the government is seen as an obstacle.

Conclusion: Energy and Work, Again

James Joule's fantasy, shared by his contemporaries, of harnessing physical phenomena to obtain unlimited energy was not mere scientific speculation, but a symptom of the economic and sociotechnical transformations taking shape at the time. Slavery was being abolished globally just as industrial capitalism (financed by capital accumulated through slave labor) was consolidating as the new paradigm of exploitation. In terms of labor, the human traction extracted by the slave regime was replaced by the energy released from burning fuel. If for a liberal conscience burdened by guilt the promotion of non-white people to the category of persons was an ethical-political achievement, for a capitalist mentality this transition merely shifted the object of exploitation from people to the environment. It is in this shift that the manufacture of metrics such as joule and watt, by framing capitalist metabolic processes, became "cleansed of all of its social and cultural dimensions and considered exclusively as a form of energy conversion, so work could be applied to nature, technology, and human labor without distinction" (Rabinbach 1990, 46), reducing nature to these terms. Hydroelectric plants, but also thermoelectric plants, nuclear plants, or any other form of capturing and storing energy, thus become material updates of modernity's reductive conceptual framing of the world.

If extractivisms of metals, timber, and oil easily evoke imagery of environmental degradation and brutal violence against local inhabitants, a hydroelectric plant, once completed, appears merely to rearrange the geographical configuration of the affected region, leaving local communities, fauna, and flora to adapt "naturally." Rhetorically, it becomes clear that

hydroelectric energy is clean insofar as it is whitewashed. This masking allows injustices and omissions in socioenvironmental reparations to be ignored, enabling clean energy to become part of what Moore and Patel (2017) call cheap nature. This whitewashing, in turn, may be understood as the performance of moral economies (Bond 2022), in which "traditional norms are not a timeless given but are selectively realized in confrontations with new regimes of exploitation. The confrontation, we might say, distinguishes past from present and sharpens what came before into an effective protest of the present" (95). If, on the one hand, the construction of the Itaipu Dam erased moral economy through the brute force of a terrorist state, Belo Monte, even amid its ongoing tragedy, reveals the tension between the latent confrontation embodied in diverse bio-cosmologies and the expansion of capitalism as a world-ecological regime (Moore 2015).

The energy consumption of data centres articulates extractive and manufacturing processes. The transformation of ecosystems into natural resources through their coupling with infrastructure amounts to a form of primitive accumulation. However, unlike cases in which the natural resource is finite, such as minerals, the players with whom I interacted regard renewable energy as unlimited.

Provided that wind and rainfall patterns remain stable (which, in times of climate change, requires a form of uninformed optimism, to cite Paulo, my interlocutor in chapter 3), this infinitude depends on respecting the rhythms of nonhuman nature. For now, capital, represented by the players mentioned in this chapter, tolerates this rhythm due to deficient transmission infrastructure. However, once the curves of supply and demand reach a sweet spot, the drive for growth will begin to covet nonhuman nature in order to put it to work a little more.

The manufacture of energy, in turn, differs from the traditional imagery of mass production associated with Fordism. Manufacturing energy, as described in the account of my visit to Peekaboo Telecom, is a form of work situated between engineering and craftsmanship. This is because there are standardized techniques for composing these spaces, particularly with regard to maintaining electrical safety. At the same time, however, there are modes of caring for the data centre environment that suggest different understandings of what is relevant or effective for maintaining machines and ensuring their energetic efficiency.

Carlos's arrangements with the cooling engine and the electrostatic isolation system, as he presented them to me, gave the impression of a scientist closer to the nineteenth-century precursors discussed at the beginning of the chapter than to the employees at Unicorn Data Centres, who presented the equipment and responded to my questions in an almost automated manner. This is not meant to romanticize Carlos's performance in contrast to that of the Unicorn Data Centres employees, but rather to emphasize how complex and treacherous physical elements such as electric current can be. Even Unicorn Data Centres's extensive machinery was not sufficient to prevent the catastrophic event that occurred weeks after my visit. As far as I could observe during my fieldwork, the ecosystem assembled by Carlos emerged unscathed from catastrophic events.

Whether or not this should be attributed to individual merit, this suggests that nature, even after being appropriated by the modern machinery of infrastructure and transformed into energy, still represents a risk. In this sense, the manufacture of electricity is not only about "cleaning" it when it arrives from the "street," but above all about controlling it in order to make it predictable. Indeed, as will be shown in the following chapters, controlling the environment by turning it into a space with an immutable present is the defining trait of data centres as infrastructure.

Chapter 5 - Information

Introduction

Something curious I learned during fieldwork is that the “data” that gives its name to this type of infrastructure is rarely a subject of discussion or concern among my interlocutors. Even though connectivity, cooling, and energy are the trinity most readily mentioned when asked what the fundamental functions of a data centre are, connectivity was extremely marginal in their actual work. From their pragmatic point of view, such a stance makes sense, since the flow of information traveling through fiber optic cables cannot be optimized in the same way that energy consumption and the management of environmental variables can. Thus, if connectivity is a prerequisite for a data centre, it is not possible to generate additional financial gain from this aspect. As one interlocutor put it, if the speed of light in fiber optics is the limit, then the challenge is to deal with the space in which the network’s nodes are located.

Thus, the chapter begins with a preliminary analysis of the proliferation of oceanic cables connecting Brazil to other continents. It is emphasized that, as value production became increasingly dependent on information, investments in cables grew, and they began transmitting greater volumes of data. This shift is symptomatic of new forms of exploitation and value production, in which digital artifacts and services—such as streaming, digital games, and cloud services—are consumed, while computational labor in data centers is exploited through the low cost of cheap energy.

Next, the discussion turns to space—or rather, to the historical occupation of informational infrastructure across space—in order to understand how new political and environmental

relations take shape around the materiality through which information exists. The analysis begins with the first attempts to establish telegraph cables, whose objective was both to integrate Brazil into the central countries of colonial capitalism and to intensify the integration of its own territory. As Winner (1980) argues, technologies do not have a politics or ideology hardwired into their functioning, but they open new modes of politics and life while reducing the possibility of others. Telegraph networks were no exception: as will be shown, the installation of submarine cables was an important event in the abolitionist struggle, as the arrival of this infrastructure galvanized liberal sentiments while also disseminating these ideals to other urban centers in the country. Contemporary to this context, the installation of telegraph networks in the country's interior had deleterious effects on the Nambiquara, an Indigenous people inhabiting Brazil's Midwest. The same network that liberates some threatens others.

Although later discontinued, the telegraph network represented an initial moment in which sociotechnical relations produced not only new modes of politics but also technical knowledge related to communication and information technologies. This knowledge is explored in the discussion of the period preceding the arrival of the internet in Brazil, up to the formation of the regulatory body that implements practices and standards for companies operating in the sector. This approach is important because it results in the context of action of an important interlocutor for this research, a technology director who has worked in the field since the BBS network era.

It is through the accounts of this director, Thomas, and of Carlos and Andrei, CEOs of Peekaboo Telecom, that the chapter explores the environmental relations surrounding the information infrastructure that composes the internet. Thomas, for example, states that for companies dealing with telecommunications and internet services, the environment is

generally not considered a variable in their operations, even though situations may arise in which ecosystem elements—such as trees falling onto cables—compromise their functioning. Carlos and Andrei, in turn, demonstrate how the urban ecosystem, with its social and architectural elements, constitutes a space of events that can put the infrastructure they manage at risk. These accounts are complemented by that of another interlocutor, Ricardo, who previously worked managing data centers in the context of mineral extraction in the northern region of the country.

With this, part of my fieldwork consisted of learning about infrastructural elements that make up the flow of information on which data centres depend. The goal here is not to exhaustively map the networks of different cables that connect devices to routers, routers to servers, and servers to switches that carry information from one continent to another. Rather, through document analysis, conversations with interlocutors, and visits to data centres, this chapter traces the technical and narrative lines along which the cables that carry information are made. These narratives are drawn from historiographic research by other scholars, documents issued by companies in the sector, and testimonies from workers in companies and institutions tied to information. To a large extent, this narrative intertwines with that of the implementation of the internet, though it is not limited to it.

Cables

Electrons are not just particles set in motion to animate objects and technological systems. In *Understanding Media* (1964), Marshall McLuhan asserts that electricity is a global extension of our nervous system. When using a speaker, a telephone, or a computer, actions such as speaking, writing, and calculating are translated–transduced into electrons. A simple example is an analog microphone, which transforms voice (air vibrations) into electrons that travel through wires until becoming sound again in a loudspeaker. For the McLuhan, this extension

amplifies the individual potential of electricity's users as it abolishes time and space, culminating in the technological simulation of consciousness. This chapter, however, pursues more modest speculative goals than McLuhan's, pausing at the midway point of this relation between informational infrastructure and environment, a relation often subsumed into "space." With the advent of modern telecommunications, first the optical telegraph, then the electric, the exercise of sovereignty took shape in the ramifications of these information networks. This sovereignty engaged both with geopolitics and war (Tworek 2019, Yang 2003), and with the internal mapping and communication of a territory, as this chapter will show.

More than a metaphor for understanding the effects of this infrastructure on its users and the world, the understanding of information networks as a nervous system served as the basis for technological and ideological developments for both superpowers during the Cold War. According to Peters (2016), ARPANET was considered by Americans to be the materialization of a distributed brain for military decision-making. The USSR, meanwhile, understood the ESS (Unified Communication System, a logistical and economic management network) as a nervous system laid across the territory as body, with the central committee as the brain where decisions were made. Thus, if Marx (2014) proposed that "[t]he mode of production of material life conditions the general process of social, political and intellectual life" (8), his insight can be unfolded by considering the co-constitutive nature of alliances between humans and their technologies.

Therefore, this chapter seeks to approach the implementation of information infrastructures in Brazil without assuming linear cause-effect relations between technology and society or culture. Along with Latour (1991), it aims to outline narratives composed of chains linking humans and non-humans. Yet while the scope in "Technology is Society Made Durable" is to

find a line of flight between poles like social context and technical content, this chapter's scope is closer to Winner's (1980) reflection on the political regimes most aligned with the risks and requirements that nuclear plants and solar panels impose within particular social configurations. Thus, the analysis here proposes that human actors appropriate technologies by projecting onto them desires and worldviews through their discourses and practices. Technologies, in turn, condition modalities of enunciation and technical procedures.

Cable Politics

If social and technological practices compose a chain of effects between humans and non-humans, then one must ask about the nature of the relations linking the terms of this chain. As argued through the dialogue between the bibliography relevant to this chapter and my fieldwork experience, economy, politics, technology, and nature are mutually conditioned. Therefore, agencies considered eminently human (such as the concentration of power or capital, or organizing for counter-hegemonic struggles) cannot be understood without considering the infrastructures that standardize the space and time of their users, fostering certain practices and discouraging others.

In territories subjected to colonial logics, modernization and the development of productive forces depend on forms of subordination to loci of capital concentration, whether imperial or investor conglomerates. In the case of information infrastructures, their cables do not simply "sprout" within a territory, but are extensions of transnational connections. Thus, in order to understand the vectors of force conditioning the development of information infrastructures, as well as how these infrastructures affect those same vectors, one must interrogate the materiality of these cables through the relations between humans and non-humans that saturate them. In her work on submarine cables, Starosielski (2015) proposes that they be

seen “not simply as technical systems, but as long-lasting contours in the environment—places where capital, labor, and knowledge have been sunk into the earth’s surface” (30).

To trace the contours materialized in these cables, it is important to examine one infrastructure now abandoned but which once played a key role in catalyzing processes of social change and territorial sovereignty during its implementation: the telegraph. Its networks were fundamental in fostering the deployment of other infrastructures and services such as electricity, public lighting, and the railway. It also played an important role in maintaining public order, such as controlling the disembarkation of enslaved people and in policing in the imperial court (Maciel 2001, 131). In its overseas extensions, it connected Brazil to northern colonial powers and intensified the flow of liberal ideas that would shape the post-monarchical society and industrial capitalism.

The installation of submarine cables has a history that dates back to the 19th century, with the deployment of transatlantic telegraph networks. These projects always involved a convergence of national and international efforts, driven both by the state (under both Empire and Republic) and by private companies. The advent of the submarine cable was seen as a powerful driver of modernization and progress, promising to “shrink the world” and make Brazil a “neighbor of Europe” (Maciel 2001, 132). Moreover, Emperor D. Pedro II hailed this event as one of the most potent agents of modern civilization, believing it would enhance social economy. It is also notable that the implementation of this infrastructure played a role in the end of slavery. At the inauguration of telegraph service, it was declared that “electricity would only begin to traverse Brazilian territory after no more slaves were born in it,” and enslaved children were freed in honor of progress. This statement referred to the *Lei do Ventre Livre* (Law of Free Birth), which prohibited children born to enslaved women after its enactment in 1871 from being enslaved.

Additionally, the rapid communication enabled by telegraphy, including submarine cables, played a crucial role in the abolitionist movement, particularly in the immediate diffusion of the *Lei Áurea* (Golden Law, abolishing slavery) in 1888. According to Figueiredo (2023), the law's phrase *"desde a data desta lei"* ("from the date of this law") implied instant validity, made possible by the speed of electric telegraphy, which quickly transmitted the news to Brazilian and world capitals, preempting resistance from slave owners. Under the supervision of operators such as W. J. Ayres, news and mobilizations circulated transoceanically, highlighting the role of the embodied labor of telegraph station operators, whose physical and technical practices became integral to the communication infrastructure itself. The telegraph's contribution to changes in social organization was not only technical but also political, through the mobilizations in which this infrastructure played a role. An example of this were the "electro-abolitionist" narratives, in which technological progress was explicitly linked to humanity's advancement toward the end of slavery (10).

The implementation of the telegraph in Brazilian territory was also a matter of ensuring control over the country's interior regions, where most of the population lived, and of (once more) attempting to assimilate Indigenous inhabitants into the State, subjecting them to its tutelage and making them productive. It was with this purpose that in 1907 the Rondon Commission, led by Marshal Cândido Rondon, was created (De Tacca 1999, 81). Rondon, a military officer of mixed Indigenous and European descent with a positivist philosophical background (Teodoro 2017, 170), saw in his work a civilizing mission to be fulfilled for the development of the nation. Among the commission's objectives were the mapping of the Mato Grosso and Amazon territories, the cataloging of Indigenous languages, and the installation of poles and bases for the setup and maintenance of the telegraph network. The commission achieved other successes as well, such as freeing the Paresi Indigenous people from slavery in rubber extraction camps, which led them to associate Rondon with a mythical

hero from their cosmology (Miller 2023), and to being recruited for the maintenance of the telegraph line.

The end of the commission in 1930 and the withdrawal of investments for the maintenance of the telegraph infrastructure led to the decay of poles, of the sites erected to sustain them, and of the communities who had built their lives around them. At the same time, the posts became targets of attacks by Indigenous groups such as the Nambiquara, which, according to Lévi-Strauss (1957), occurred because they mistook the sound of electricity for the buzzing of a beehive (287). It should be noted that the French anthropologist's account refers to his expedition into the Brazilian hinterlands in the 1930s, at the time of the aforementioned disinvestment, so that the Indigenous attacks sound like a consequent reclaiming of territory. Miller, on the other hand, questions this interpretation, proposing speculation about the relation between Nambiquara cosmology and the modern infrastructure that had been installed in their territory. In conversations with young Nambiquara Mamaindê, they reported an increase in whirlwinds, common phenomena during the hot season that signal the presence of aggressive spirits, which mainly sicken women and children. Against these entities, shamans asked that cell phones not be used, as spirits entered through electrical lines. Miller argues that her account and that of Lévi-Strauss are different moments of a war between Indigenous peoples and the invaders of their land.

The type of war suggested by Miller is not waged through materiality as understood by moderns, that is, through a dynamic of occupation-resistance over territory understood in Cartesian terms. This does not mean that the Nambiquara failed to grasp the kind of threat a modern undertaking, whether extractive or "civilizing," represented. Nor is it a matter of relativism in which the difference lies in the interpretation of an objective reality. The war proposed by Miller rests on new relations of alterity provoked, in this case, by the encounter

between the Nambiquara and infrastructural lines. Thus, the issue is not to villainize the telegraph and the institutions and individuals invested in its implementation, but to understand its effects and potentialities upon people and their respective worlds.

An analogous argument can be made about Ceará at the end of the 19th century: just as Rondon's positivist humanism led him to free enslaved Indigenous peoples, the implementation of the first telegraph cables in Ceará was conditioned by the abolition of slavery. Needless to say, a technology like the telegraph is not a herald of benevolence and justice, but something that reconfigures space and time, and along with them, the cosmologies, epistemologies, politics, and economies of the humans immersed in them. It is by considering the transversality of these sociotechnical processes that the cables connecting Brazil will be approached.

Cables in Contemporary Brazil

It can be said that the implementation of informational infrastructure in Brazil in the second half of the 20th century is divided into two periods. The first, carried out by state-owned companies, was responsible for cost and demand planning, equipment purchasing, and labor use. The second phase, beginning in the late 1980s and continuing into the early 21st century, was marked by the privatization of public companies and the opening of the market to foreign capital. Thus, with the advance of technology and the emergence of the internet in the late 20th century, there was a dramatic expansion in the installation of submarine cables. According to Starosielski, "[d]eregulation, privatization, speculation about increases in capacity that would be needed by the growing Internet (…) drove a global boom in cable laying" (2015, p. 48). This "cable boom" was a response to the growing demand for communication infrastructure and to the perception of the internet as a promising new market, especially after the "dot-com bubble."

This period of global cable expansion was marked by considerable speculation regarding the internet's future needs. One need only recall Clifford Stoll's famous prediction that the internet would not prosper[17] (and, ironically, for reasons for which we now lament its hegemony). Uncertainty about the adoption of digital services implied risks for investors, who had to coordinate cable production, the operation of specialized ships for their installation, and both marine and terrestrial maintenance with the social and economic demands of the time. This technological articulation cannot be understood merely as a market-driven response. As Carvalho (2006) observes in his reading of the stabilization of this kind of artifact, "for ARPA researchers, it was enough that ARPANET worked for it to be considered a ready technology, whereas for the community of potential users, (…) it was necessary that they be convinced of its functioning" (20).

Thus, Carvalho argues that a technology, even if completed as ARPANET was, requires the adherence of users for it to effectively function, so that its performance is negotiated with the people it was built to serve. Similarly, the implementation of submarine cables would only stabilize as infrastructure if the user community recognized their value and functionality. If life with the internet today is an inescapable fact, it required the alignment between the potential functioning of what this infrastructure offered and how that functioning would be adopted by its users, both in practice and in imagination. There is, therefore, a play of forces involving public policy for the implementation of technology, capitalist actors exploring the possibilities of value to be extracted, and society with its diverse modalities of relations and subjectivities. In this way, one avoids a technological determinism that sees the internet solely as an inevitable materialization of neoliberal principles of free capital and information flow.

17 The responsibilities of a solutions architect include mediating between client needs and coordinating the team responsible for delivering the project and its implementation; it is thus a role that involves both technical and communicational competencies.

In Brazil, the trajectory of submarine cable implementation paralleled the development of the global internet but with its own specificities. By the late 1990s, the presence of foreign telecommunications companies was dominant, especially with North America serving as an intermediary in Brazil's data communications. This scenario began to change in the 2010s. A significant milestone was the installation of the EllaLink cable, the first to connect Brazil directly to Europe without passing through the United States. This shift in the geopolitics of digital infrastructure signaled an advance in Brazilian autonomy in terms of international connectivity and the formation of regional alliances in the Global South.

The installation of submarine cables in Brazil also benefited from the entry of major technology companies into the sector, such as Google (Firmina cable) and Meta (Malbec cable). Google has invested in cables connecting different regions along the Brazilian coast, while Meta has been involved in projects linking Brazil to the United States. These investments show how big tech companies are reshaping the digital economy, influencing the development of strategic infrastructures that in the past were dominated by telecommunications companies and governments. This new role of big techs in the global submarine cable infrastructure reflects a transformation in the digital economy, where control over data infrastructure becomes a crucial competitive advantage.

Beyond the geopolitical and economic shift, the issue of submarine cable infrastructure is closely tied to narratives of connection and progress. Starosielski notes that "companies seeking to build an undersea network must build an imagined world around the cable project, using narratives of connection to generate confidence in the proposed network" (2015, 60). These narratives play an important role in persuading investors, governments, and users of the importance and feasibility of such projects. In the Brazilian context, submarine cables are often presented as a solution to improve national and international connectivity, as well as a

way to promote the country's integration into the global digital economy. A symptom of this is the emergence of alliances between data centre companies such as Equinix and EllaLink[18], making it clear that the synergy between data centres and submarine cables changes the dynamics of technology and capital.

In recent years, submarine cable infrastructure has become an essential part of Brazil's integration into the global digital economy. With EllaLink directly connecting Brazil to Europe and new cables financed by big techs, the country has gained a more diversified and autonomous network compared to the past, when its connection with the rest of the world depended almost exclusively on cables passing through the United States. This represents an important step toward technological independence and the building of new geopolitical alliances. The entry of big techs into the sector also reflects a new phase in the digital economy, where these companies are not only offering digital services but also shaping the infrastructure that enables them.

However, the installation of submarine cables in Brazil still faces significant challenges. The long-term nature of these investments and the technical complexity involved in laying cables across the ocean are obstacles requiring careful planning and coordination between the public and private sectors. The maintenance and upgrading of these infrastructures are equally critical, especially as data consumption continues to grow exponentially with the rise of streaming services, videoconferencing, and other high-bandwidth applications.

The submarine cable structure in Brazil is closely tied to issues of digital sovereignty and the strategy of expanding internet access in a global scenario where data has become one of the most valuable assets. Controlling the infrastructure that transports this data, such as submarine cables, represents a form of power. In this sense, developing a network that does

18 Laís Martins and Francisco Amorim, "TikTok construirá mega data center em cidade com histórico de seca no Ceará," *Intercept Brasil*, May 22, 2025.

not depend exclusively on routes passing through the United States or other global powers is crucial to increasing the country's digital autonomy. This digital sovereignty not only protects Brazilian data but also strengthens Brazil's role in internet governance and in the future of the global digital economy.

This effort was complemented by the implementation of the National Broadband Plan (PNBL) in 2010, with the goal of massifying internet access by 2016. The plan aimed to ensure that nearly 100% of Brazilian municipalities had access to internet services with a minimum speed of 1 Mbps. In addition, it offered the free, on-demand availability of a broadband access link of 2 Mbps for a public access point in municipalities with up to 20,000 inhabitants, with more points offered as population increased. It is also important to emphasize that the implementation of submarine cables is not only a technical or economic phenomenon, but also a process deeply rooted in political, social, and environmental issues. As Starosielski argues, "there remains a fundamental conservatism in the cable industry that dates back to the telegraph era, and many of the companies remain aligned with, though not beholden to, national governments" (2015, 61). This conservatism manifests both in the way submarine cable companies operate and in the alliances they form with governments and other firms. More than a desire for technological modernization, the recent development of submarine cables indicates an attempt to reposition the country in a global scenario increasingly dependent on data infrastructure.

The table below shows, in chronological order of effective operation, the submarine cables that connect Brazil with other countries, their owners, and their transmission capacity in terabits per second:

South America Crossing (SAC); 2000; Cirion Technologies and Sparkle; Not specified;

GlobeNet; 2001; GlobeNet; Not specified;

South America-1 (SAm-1); 2001; Telxius; 20 Tbps;

Seabras-1; 2017; Seaborn Networks and Telecom Italia Sparkle; 72 Tbps;

Monet; 2017; Algar Telecom, Angola Cables, Antel Uruguay, Google; 64 Tbps;

Tannat; 2018; Antel Uruguay and Google; 90 Tbps;

BRUSA; 2018; Telxius; 160 Tbps;

South Atlantic Cable System (SACS); 2018; Angola Cables; 40 Tbps;

Malbec; 2021; GlobeNet and Meta; 108 Tbps;

EllaLink; 2021; EllaLink; 72 Tbps;

Firmina; 2024; Google; 20 Tbps.

More than the average increase in the bandwidth capacity of each cable, what is striking is the intensity with which these projects began to be inaugurated from the late 2010s onward. This frequency contrasts with the uncertain and tortuous scenario described by Starosielski, allowing us to infer that the implementation of a submarine cable is no longer merely a risky gamble by a group of economic actors, but a necessary component of an ongoing process of capitalist expansion. This expansion depends on the acceleration of information flows and, consequently, on a persistent struggle against space—an effort to compress distances, reduce latency, and render communication increasingly instantaneous. Obviously, for the shareholders investing in these cables, the Cartesian space in which they are situated does not expand, and the time that governs their existence is a straight, inflexible line.

As shown, these flows produce effects beyond the economic dimension, fueling forms of resistance and social change. However, the development of this network of cables, servers,

points of presence, and other infrastructural elements that make up the Brazilian internet tells only half the story of the country's information infrastructure. More than understanding how capital and technology were materialized to connect Brazil with the rest of the world, it is necessary to understand how domestic information networks were constituted.

Prehistory of the commercial internet: military and academic actors

Unlike other technologies, such as electricity itself, the commercial implementation of the internet in Brazil occurred not long after in the United States. However, before outlining how the current information infrastructure was established in Brazil, it is important to highlight two moments in which a data transmission infrastructure was envisioned not only as a national integration project but also as a way of connecting academic networks with foreign universities. For this purpose, works that critically synthesized this historical process were chosen. Carvalho (2006) provides a historical account of the internet's trajectory in Brazil, from the initial emergence of computer networks to the establishment of its governance mechanisms, seeing it as a complex sociotechnical construction. Fanfa (2023), in turn, investigates the internet's infrastructure and its social aspects, particularly the territorial inequalities that shape the process of mediatization in Brazil. Documents published by the Brazilian Internet Steering Committee (Comitê Gestor da Internet, CGI), an autonomous body made up of technical experts that sets guidelines for policy formulation and regulates norms for the country's internet, were also consulted.

During the Brazilian military dictatorship (1964–1985), the government sought to consolidate control over the country's integration, both territorially and in terms of data and technology, as part of an effort to modernize national infrastructure and guarantee sovereignty against foreign influence. In this context, discussions on the "information society" and "telematics" became central to government agendas and to the computing and telecommunications sectors.

These discussions were spurred by reports such as Nora-Minc, quickly translated into Portuguese by SERPRO, reflecting the urgency for Brazil to position itself in global technological debates. The convergence of telecommunications and computing in Brazil also took place in events such as the VII Panel of the Brazilian Telecommunications Association (Telebrasil) in May 1978, where the "marriage" between these sectors was discussed as a strategy to strengthen state control over technological development. Furthermore, in 1979, Telebrás announced the Latin American Computer Network Project (REDLAC), an initiative aimed at advancing research in networking technologies—particularly packet switching, local networks, and interconnection—alongside institutions such as CPqD and USP.

The military government's industrial policy for the telecommunications sector was implemented in three phases, always aiming to ensure the development of domestic technology and reinforce national control over telecommunications. Initially, it sought to attract foreign capital and technology, offering annual contracts and market reserves in return. The second phase focused on nationalizing the capital of foreign companies, requiring majority participation from Brazilian partners. Finally, the third stage sought not only to manufacture equipment domestically using foreign technology but also to develop national technology, creating joint ventures or nationalizing companies. The government used the purchasing power of the Telebrás system to encourage majority-national companies, as part of an import-substitution strategy. However, despite these efforts, leading telecom companies remained multinational, maintaining decision-making control abroad through legal maneuvers while securing their share of the Brazilian state market.

Concomitant with this state-driven attempt to ensure sovereignty and territorial control, another initiative arose from Embratel executives (the state company responsible for coordinating telephone infrastructure implementation in Brazil) and members of the Brazilian

academic community. In 1982, Embratel launched *Ciranda*, a pioneering information services network restricted to its employees, consisting of an internal teleinformatics system. To make the project viable, the company provided shared microcomputers in its offices and financed the purchase of Prológica CP-500 microcomputers with modems, so that employees could use them at home. The central system could serve up to 300 simultaneous users, and about 2,100 employees across more than one hundred cities participated, forming Brazil's first teleinformatics community. The project was presented as a way of democratizing the use of teleinformatics, simulating active participation in a community where users could interact and make collective decisions. Announced at the XV National Informatics Congress of SUCESU (Sociedade dos Usuários de Tecnologia) in 1982, the Ciranda network represented an early attempt to integrate data communication technologies into the daily lives of its users, a precursor to future national efforts to modernize the country's digital infrastructure.

The official launch of the National Education and Research Network (RNP) in 1989, under the leadership of Tadao Takahashi, marked a milestone in building Brazil's internet infrastructure. RNP was the first internet backbone in the country, though its initial capacity was enough only to serve universities included in the network. *Backbone* is a term with imprecise technical meaning. An internet backbone is a central network of cables that connects different regional and local networks, enabling large-scale data exchange. The term is used loosely, meaning that both submarine cable networks and inter-university computer networks may be called backbones. In the context of RNP's creation, its architecture was inspired by the U.S. NSFNET and consisted of three levels: the national backbone, regional networks, and institutional networks. The national backbone, funded by the federal government, connected regional networks responsible for linking institutions in specific geographic areas and also established international connections. This model was crucial for

structuring the expansion of the internet in Brazil, ensuring that universities could connect to each other and to the world, paving the way for the network's development in the country.

Thus, the importance of a backbone such as RNP lies in its ability to ensure efficient communication between different networks and regions, providing the technical seeds of Brazil's modern internet. Moreover, the backbone's creation was a fundamental step for national technological integration and for the country's insertion into global discussions on computer networks and the internet, even though, at first, it served only a restricted public.

Elements of contemporary Brazilian information infrastructure

The efforts described above show both the technical potential for implementing digital technologies and the academic interest in connecting computers across Brazilian and international institutions for scientific collaboration. If the submarine fiber optic network carries colonial historicity and the geopolitics of data, the subsequent domestic networks also constitute social and economic arrangements aimed at fostering an informational infrastructure. Thus, although computer networking experiments in the 1980s were predominantly restricted to the academic sector, they were carried out by elites from the country's leading institutions, who then joined committees that laid the groundwork for the establishment of the internet in Brazil, such as the Internet Steering Committee. It was this committee, for instance, that established *.br* as the address for Brazilian websites and implemented the adoption of protocols that would later underpin the commercial internet, such as TCP/IP.

It was through the nascent infrastructural and institutional development of the early 1990s that the commercial internet began to unfold. According to Demi Getschko, co-founder of the committee and one of the main agents behind the internet's implementation in Brazil, this

development happened in waves, with different actors entering the scene: equipment manufacturers, bulletin board system (BBS) providers, activists, and finally telecom providers, who realized it was "better to abandon their ISO/OSI connection plans and start delivering TCP/IP.[19] One of these actors is Thomas, CTO of a company providing connectivity and security services. Although the company has an office in São Paulo, most of its employees work remotely from different regions of Brazil. Beyond his professional career, Thomas enjoys a prestigious reputation among his peers, with a significant social media following and regular participation in podcasts and events to discuss IT topics, often framed through his political perspective. Curiously, his academic training was in biology, and he began teaching high school biology. His career in the internet field began as something between a hobby and a necessity. According to him, in the 1990s, the labor force and technical knowledge for internet implementation and maintenance were incipient, and self-taught users often helped ISPs troubleshoot problems.

Thus, according to Thomas, the user back then was a category with greater agency, playing an active role both in solving technical problems and in deliberating over the governance of this infrastructure. He adds that these users often paid high access fees and purchased servers and equipment. This hands-on experience gave him deep technical knowledge, which he believes is often missing in formal computer science education today. He sees himself as an "eyewitness" to the construction of the internet in Brazil, giving him insights that even formally trained engineers might lack.

This privileged experience profoundly shaped his worldview, as he sees the internet as "humanity's greatest work" (Interview with Thomas, by author, Zoom, November 8, 2024)

19 This number differs from counts produced by other sources. Market consultancies such as Macquarie, websites such as the data aggregator DataCenterMap.com, and institutions such as the Uptime Institute report a much smaller number. The authors' method consisted of aggregating results obtained from PeeringDB (a free network database), DataCenterMap, the Uptime Institute, and the Telecommunications Industry Association, excluding duplicate entries

This caught my attention because it was one of the first things he said in the interview, and the terms used are far from trivial. First, the evident generalization: across all cultures and cosmologies created since the first humans began articulating language, to those now extinct or assimilated by modernity, nothing, according to this statement, matches the internet. Second, "work" should not be taken in its everyday sense, but as a legacy that marks the efforts of a generation, whose grandeur is parallel to mythical endeavors, like the Tower of Babel. Thus, more than a technological turning point, Thomas's statement endows the advent of the internet with a teleological connotation, articulating an idea of humanity bound to digital information infrastructure.

He also mentioned a protocol for the internet to function in space and on other planets. This remark is interesting because, although it may appear as technological fetishism fueled by ideologies of colonization and domination (like the infamous "Colonize Mars" t-shirt), one can also view internet expansion as a later phase of the slogan "Information Wants to be Free," coined by Stewart Brand and appropriated by free software activists. In this sense, this "work" transcends borders not from a colonial impulse, but anchored in the belief that the collective effort of global knowledge production lies at its core. These borders, in turn, are not only those defined by the Earth but also the institutional ones subordinated to national governments.

In this regard, Thomas warns of "collisions of worlds," where national agencies (such as Anatel, the telecom regulator) overstep their authority by issuing block orders on internet content (e.g., pirated cable TV), which lies outside their traditional regulatory scope. He also cites censorship, cyberattacks (such as in the Russia–Ukraine war), and arrests over VPN use as signs that the internet is being "dilapidated" and its open nature compromised. His stance is particularly relevant while writing this chapter, as countries such as Denmark and Brazil

are taking steps to legislate on big tech's responsibility for social media content, particularly regarding child exposure and abuse. For Thomas, irreducible to a simple State vs. Capital dichotomy, the internet is a *commons* based on knowledge production and circulation. His critique, therefore, is directed at the instrumentalization of this infrastructure by governmental and capitalist actors.

To support his critique, Thomas notes that internet users are increasingly seen as mere consumers rather than partners or co-creators of the network, undermining its original spirit of openness. He also highlights a significant generational divide in understanding the internet's physical reality. According to him, many current IT professionals, especially programmers, lack a basic grasp of physical infrastructure. They perceive the "cloud" (Amazon, Microsoft Azure, Google Cloud) as immaterial and fail to realize that a server is a physical computer in a data centre, which is essentially rented real estate. This gap in knowledge prevents them from understanding the foundational support behind the websites they build.

During our conversation, I asked him to what extent the environment was a relevant factor for internet operations. According to him, both telecom operators and ISPs generally show an "absolute unawareness" of how climate change will affect their infrastructure and business. He suggests they see themselves more as "utility" companies (like water, gas, or energy providers) than as technology companies, leading to a disconnect from climate concerns. For these companies, the main concern is service interruption, but they have not yet successfully correlated such interruptions with specific climate events. He uses the analogy of a cat that cannot associate past actions with present consequences to describe this industry-wide lack of association. In this sense, he sees redundancy measures, common in data centres, as a reactive posture toward climate events.

His perspective is not based merely on impressions but also on practical experience. For example, he describes a project he implemented to correlate meteorological data (rainfall, wind speed, temperature) with network incidents (power outages, equipment overheating) in order to predict and prevent service disruptions. To do so, he sought to purchase detailed weather bulletins for alerts on specific geographic points of his network, which led his colleagues to see him as revolutionary. Beyond his individual ingenuity, this account is symptomatic of the broader disconnect between ISPs and climate as a relevant factor in operating such businesses.

Another professional experience he recounted involved a hill within a protected ecological reserve, topped by three telecom towers, one of which belonged to the company he worked for. Surrounded by trees, these towers were frequently impacted by falling branches and trunks. However, since the area was environmentally protected, cutting branches still attached to trees was forbidden, let alone building an equipment post for maintenance. Worse still, the tower's location was hours away from his home, and access to the hilltop was possible only on horseback or on foot. While Thomas does not suggest that the environment itself is "to blame" for internet infrastructure failures, it is noticeable that the interplay between infrastructure, environment, and state regulation mediating this relation is fraught with conflict.

Streets and Their Perils

Before founding Peekaboo Telecom, Carlos and Andrei had experience managing an Internet Service Provider (ISP). From the user's perspective, an ISP is the starting point for browsing the internet. From the user's home or business, traffic enters the ISP's network through access switches, which connect client devices, and then passes through distribution switches, which aggregate data from multiple access points and forward it to higher-capacity

equipment. Because they work at the edge of infrastructural networks, ISP companies are "pioneers," since they invest in the initial infrastructure of a region (also called "last mile"). This investment, however, is never guaranteed, as not every area with internet demand has the basic conditions for its installation. Cities in remote regions far from urban centres, for example, represent an additional logistical challenge for laying cables and installing equipment. Another challenge for these companies is operating in regions dominated by criminal factions, which impose fees for operating in their territories, sometimes even destroying the property and equipment of these companies when they encounter resistance[20].

In some cases, if the user and the server are on the same ISP, all traffic stays within that network, making it fast and direct. But most of the time, content comes from distant locations. To reduce the distance traveled by packets (bundles of data transmited between devices) and improve the experience, CDNs (Content Delivery Networks) come into play. A CDN is a geographically distributed network of servers that cache (temporarily copy) content such as videos, websites, and files. Thus, when a user requests content, it is delivered from a nearby server, reducing latency (the delay from the transmission of data), increasing speed, and also offering more security and resilience against failures and attacks such as DDoS[21]. When there is no nearby CDN or when data needs to leave the original ISP, traffic exchange takes place at an IXP (Internet Exchange Point), which is the case for Peekaboo Telecom. An IXP is a physical infrastructure where different internet providers and network companies connect with each other to exchange traffic directly and efficiently, without relying on intermediaries.

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20 Mordor Intelligence, *Brazil Data Center Market – Growth, Trends, COVID-19 Impact, and Forecasts (2025–2030)*, accessed January 7, 2026, https://www.mordorintelligence.com/industry-reports/brazil-data-center-market.

21 Jon Henley, "Ireland's Data Centres Overtake Electricity Use of All Homes Combined, Figures Show," *The Guardian*, July 23, 2024, accessed January 7, 2026, https://www.theguardian.com/world/article/2024/jul/23/ireland-datacentres-overtake-electricity-use-of-all-homes-combined-figures-show.

In recent years, Peekaboo Telecom has entered the data centre market because, according to Carlos, the company's dependence on data centre services made it economically advantageous to invest in this infrastructure themselves. This trajectory sets it apart from its peers, as it is located in a shopping mall and has a geographically horizontal expansion plan. According to Carlos, the viability of the plan lies in the physical proximity between client and infrastructure, which allows for visits, maintenance, and lower latency. The strategy is to spread several smaller data centres throughout the metropolitan region of São Paulo, reducing the distance information needs to travel—since the speed of light is the physical limit of traffic. In this context, my interlocutors prefer operating data centres to offering internet services.

Their response struck me as odd, because in meetings with data centre managers it was common to sense urgency and permanent crisis. When asked about the reason for this preference, they explained to me that the environment of a data centre is controlled, so problems are contained within the infrastructure they manage. Even external mishaps that could lead to disruption can be translated into variables that, if planned for, can be monitored and controlled. The same, they said, cannot be said for operating internet services, because "money is volatile, it stays in the street." By this, they mean that their equipment, costly to purchase and install, is subject to weather conditions and the risks of accidents and crime. Again, the street as an element that interferes with value. But whereas in the case of electricity the street represented a work opportunity (cleaning the energy and reselling it at retail to clients), here the street is a threat to business, a source of negative value. In addition, Carlos and Andrei claim that the attribution of responsibility by clients is not always fair, as all the variables of the street, even those outside Peekaboo Telecom's scope of operation, are delegated to them.

Thus, according to my interlocutors, “street” is more than just a literal place; it is also a territory of emergent events whose map is constantly shifting. As economic agents, Carlos and Andrei see the street as a place where value dissipates. But how exactly is the street a factor of value loss? With the concise and somewhat enigmatic answer they gave me, I was reminded of a promotional video in which they show a Point of Presence (that is, an access point for different networks, usually linking an Internet Service Provider to its clients) located on private property, whose owner rented out part of it for the installation of a tower connected to power and fiber-optic cables.

The video shows both the typical security artifacts for maintaining private property: walls, cameras, barbed wire and the devices to ensure uninterrupted power supply for the server racks, such as grounding systems and diesel generator outlets. In this sense, private property and flows of energy and information are co-dependent. Electricity powers both the electric fence that protects the tower and the security camera that monitors the property’s perimeter. The fiber-optic cables, in addition to enabling connectivity for the servers that constitute Peekaboo Telecom’s raison d’être, also transmit the images recorded by the camera.

Thus, the Point of Presence presented here consists of infrastructure located within private property. This property, in turn, protects the infrastructure, one of its security devices being a camera connected to Peekaboo Telecom’s information network. This circularity between infrastructure and security is, from a preliminary perspective, simply the description of a mode of private property. For a capitalist society like Brazil’s, such a description is trivial. Less trivial, however, is understanding that ensuring the inviolability of the private property on which infrastructure is located (in this case, the Point of Presence tower) is just as important as the infrastructure’s technical functioning. For the street is not only a place of accidents and exposure to the elements, but also the point of vulnerability of transpassing.

Thus, the security of an infrastructural element such as the PoP depends on its condition as private property, so that private property is not merely a legal premise of liberal political theory but also a technical necessity for the functioning of essential services.

As a place of circulation of value, labor, and goods, the city is at once the condition for flows and a chain of obstacles to their occurrence. Traffic jams, a necessary phenomenon in societies designed for cars, are an example of this. Carlos's struggle lies in understanding this contradiction and leveraging it to gain competitive advantage over his competitors. To this end, some of his procedures regarding urban space can be summarized as follows:

1. Information infrastructures require techniques of enclosure, ranging from the trivial maintenance of private property to measures designed to insulate them from weather effects;

2. The critical points of an infrastructure, such as data centres, must be distributed so that the flow of work and information occurs without interruption;

3. The value generated results from this dual process of enclosure and flow. Thus, urban space is reconfigured: channels of energy and information are created and redirected, buildings unrelated to their surroundings are erected, and transportation routes are intensified or abandoned.

A similar account emerged in a conversation with Ricardo, a coordinator of an academic research network. He is designed to maintain and ensure the performance of the servers at one of the network's nodes, located in a federal university in northeastern Brazil. His experience, however, is somewhat unconventional: before his current role, he managed

servers embedded in mining machinery in the Amazon region, ensuring performance and connectivity between devices. I found it curious that an activity of primary accumulation, such as mineral extraction, would require high-performance computational work. He explained to me that the extraction machines are remotely operated, and their operation depends on data collected by sensors, which are affected by excavation debris and calculated to produce information interpretable by the operator. Such a procedure demands real-time calculations in server clusters (which Ricardo referred to as small data centres) inside the extraction machine, which send the processed information to a remote station where the machine is controlled. Thus, the integrity of fiber-optic cables is fundamental to this enterprise.

This career trajectory, from the private data centre sector to the public research network sector, seems counterintuitive. With the growing appreciation of renewable energy and increasing demand for processing infrastructures, the data centre sector has recently become prominent. If we take into account what data centre players say, an expanding market with a shortage of qualified labor should encourage highly specialized workers to seek professionally advantageous positions. Indeed, my interlocutor's point of view called into question common-sense assumptions about economic dynamics in the public and private sectors—where the former is associated with waste stemming from the tragedy of the commons, and the latter with profit-driven efficiency.

In this sense, I asked him about the different relations with machines and their uses, levels of efficiency in resource use, and production bottlenecks between his previous experience in the private sector and his current one as a public employee. According to him, the public agency that employs him manages resources and demand in a way that can provide good levels of connectivity to users without exhausting material resources, thus being more efficient. On the

other hand, in his private sector experience, he reported that the intensive use of data centre resources surpassed the threshold of proper machine functioning, thereby delivering a poorer-quality service. This “machine fatigue,” stemming from energy-computational exploitation, had not previously been mentioned by my interlocutors.

Another aspect shared by this coordinator was the ambivalent materiality of information. According to him, the terrestrial fiber-optic network is subject to various mishaps, from drunkards and people using repeaters as target practice on poles, to kites with glass-coated string. The “street,” this space where, according to Carlos and Andrei, value is put at risk, reappears—this time with aspects that highlight not only the uncontrollable nature of climate and crime, but also the crooked walk of a drunkard and the sometimes-dangerous play of a child. At the same time, heat and other environmental variables do not present the same risk, according to him. Another noteworthy detail, mentioned casually by him, was the occurrence of an arrow piercing a fiber-optic connection point in a region near where the mining machinery was located.

I was struck by the trivial way Ricardo mentioned the arrow lodged in the connection point, as one among many events that disrupt the functioning of infrastructure. For a social sciences student, or for those acquainted with the violent march of progress, particularly regarding the advance of the Brazilian state over the “green hell,” this arrow could be interpreted as friction against that march. But for an operator of such infrastructure, it is equivalent to a drunk throwing a bottle at a pole or a strong wind damaging overhead cables. In the context of this research, an arrow stuck in equipment recalls the violent removal of Indigenous peoples for projects like Belo Monte, as mentioned in the previous chapter. It is not, however, a matter of passing judgment on Ricardo’s sensitivity to cosmopolitical issues. In fact, he showed critical —albeit cynical—awareness of the violence perpetrated by a mining company. In this regard,

he reminded me that we were conversing thanks to minerals extracted precisely through that violence.

More than a sharing of resigned guilt, the conversation with him was eye-opening, showing me that data centres are not only concrete behemoths thirsty for energy and water, but also vary in scale so they can process on-site the machines that extract minerals. Thus, fiber-optic cables do not slash through the forest the way the Trans-Amazonian Highway did, nor do they flood hectares of forest like a dam. They traverse a space—be it a peripheral suburb or a rainforest—in order to implement technologies of digital recoding in the territory where the network node is located. In this sense, it is interesting to note how two forms of extraction are at play in this modality of data centre: the first, in its most common sense, as a means of intensifying mineral extraction; the second, through the transformation of the extraction activity itself and the matter it affects into information.

This dual extraction is only possible because the informational component of data centres rests on the premise of reducing topography to topology. In other words, it matters little whether the fiber-optic network crosses a forest or a metropolis, as long as the risks to it are mitigated and fixed when they occur. This indifference to the environment is an equalizing device that places on the same scale political issues such as Indigenous resistance, urban security, and climate risk. Thus, if there is such a thing as “seeing like a data centre,” one of its sensory organs reduces threats of heterogeneous nature into disturbances of different intensities. These “organs,” in turn, are not only the materiality of fiber optics and the equipment they connect, but also their human operators who install, monitor, and maintain them. This work around the cables and the information network they compose points to a dual process of penetrating a space and a form of existence alien to it.

Above all, it is through maintaining this non-relation with the environment that the internet and other networks function, leading, for example, to the techno-triumphalism of a "network society" (Castells 1996). If one can distill a message from this medium, it is that this technological network eliminates space, connecting digital devices and their servants. However, insofar as it is an ideological discourse, this message is grounded in the labor that preserves its material integrity. This labor is a play of forces between this modality of capital-laden sociotechnical assemblage and the state's security apparatus on one side, and, on the other, the intentional or emergent phenomena, human or non-human, that disturb the free flow of information.

One Man's Noise Is Another Man's Signal

When I asked Thomas precisely how he understood the notion of information, he clearly distinguished data from noise, which he considers garbage because it lacks meaning and is unwanted in transmission. For Thomas, data does not possess inherent value. Instead, its worth is contingent upon its extractability and its capacity to hold significance for a human or a machine. To support his position, he illustrates this by referencing the "SNR" (Signal-to-Noise Ratio) in telecommunications, where a higher proportion of signal (meaning) to noise indicates better quality and value. Thomas did not specify whether "value" here is meant in its economic sense. However, this lack of clarity is a productive opening to explore the meanings of value and information.

The opposition between signal and noise is not fixed but shifts according to the technologies available. Thomas highlights that what is deemed "noise" can transform into valuable "data" over time with technological advancements, particularly with artificial intelligence. For instance, ambient sound recordings that might have been considered "noise" 15 years ago due to the computational effort required to process them can now be analyzed by AI to extract

meaningful information, such as conversations that could generate targeted advertising. In this way, computational work transforms noise (garbage) into information (value). This example is interesting, for it argues in favor of a virtually unlimited reprocessing of externalities that can otherwise hinder value generation. This type of externality, socio-ecological in nature, is designated by Moore (2015) as negative value. According to him, "[t]he accumulation of negative-value, immanent but latent from the origins of capitalism, is now issuing contradictions that can no longer be 'fixed' by technical, organizational, or imperial restructuring" (268). If in Thomas's example this negative value becomes surplus value again, it is worth returning to the examples of Ricardo and Carlos. To do so, one must delineate how the analogies of garbage-noise and value-signal are conceptualized within this infrastructure.

Analogies involving garbage and value are not new in computing. Programming languages, for example, may have processes that perform "garbage collection," that is, cleaning up memory allocated by a program that is no longer referenced during its execution and has thus become useless. In this sense, garbage is a residue of prior activity that continues to consume resources unnecessarily, constituting waste. Noise is a type of garbage that contaminates the possible quality (value) of a piece of information, as when a file is corrupted, potentially compromising the functioning of a program or computer system. More than a mere analogy, these ideas emerge from the intersection of cultural values and technological practices that condition how these actors understand space, whether that be an urban metropolitan zone, as in the case of Peekaboo Telecom, or a forest, as in Thomas's experience.

What kind of understanding equates the suburb of a metropolis with one of the world's richest biomes? Instead of grappling with the ambiguity of such an equivalence between antagonistic spaces (forest and city) the aim, following Moore (2011), is to think in terms of a

world-ecological perspective, in which “environmental history is every bit as much about factories as forests, stock exchanges, shopping centres, slums, and suburban sprawls as soil exhaustion and species extinction” (34). In this sense, fiber optic cables, points of presence, arrows thrust into these points of presence, cable thieves, gusts of wind, the author of this thesis, his interlocutors, and the computer he uses to type these words are all elements that constitute a capitalist environment. These elements, however, do not exist in and of themselves but rather through diverse relations among them.

Returning to the first point of Carlos’s synthesis about his procedures in the urban space for installing a point of presence, it was established that this constitutes an enclosure of that infrastructural part. This enclosure is oriented both toward climatic elements such as power outages and lightning strikes and toward social elements, particularly regarding the maintenance of private property. From the standpoint of an information infrastructure, which my interlocutors operate from their technical designations, a lightning strike and a drunkard throwing a bottle at a server are equally sources of an event that can generate noise. In other words, they are externalities that produce “garbage” ranging from corrupted information to service interruption, one of the greatest fears my interlocutors reported throughout the fieldwork. When Carlos explains his difficulty in running a telecom by saying that the money (i.e., the assets, or dead capital) is out on the street, it is precisely because the street is the place where garbage proliferates, both in its literal and moral sense, and now, with Thomas’s account, also informational.

Therefore, the street and the forest, although radically different spaces, share among them the possibility of random encounters and emergent interactions. Some of these contingencies include: a drunk person, like the one mentioned by Ricardo, deciding to damage a server mounted on a utility pole; a slightly stronger gust of wind bringing down a structure and

damaging a Point of Presence; a truck carrying a load higher than permitted becoming entangled in a fiber optic network. These events (and others more complex, involving chains of actions and intentions) do not fit neatly within the set of possibilities that might typically affect, for example, a fiber optic network.Could these disruptions be what Moore understands as negative-value?

For Moore, this modality of value arises from the climate crisis and its effects on Cheap Nature, particularly in agriculture. The increasingly high costs of planting make the harvest a progressively less attractive commodity. This is because factors such as impoverished soils, irregular rainfall, and more resistant pests all compose negative-value. Dealing with these problems makes the commodity-money-commodity transition increasingly less attractive for the producer. Similarly, social inequality and worsening climate phenomena are problems that affect my interlocutors, even if, as Thomas points out, they do not recognize them as such. For now, the aggravation of these socio-ecological processes can be understood as a business opportunity for my interlocutors. More traffic in a large city means exploring spaces outside the jammed zones. More thefts of cables and information equipment demand more services and security devices. Heavier rains require more UPS systems and shelters more resistant to wind. As long as there is a market with favorable operational costs, the garbage produced by the capitalist environment will not be a threat but an opportunity.

When these infrastructures enter forests, as in the cases reported by Thomas and Ricardo, the relation between waste and noise needs to be a little more elaborate. After all, to say that a forest starts producing waste precisely when agents of “progress” begin to occupy it would be a gross inversion. What kind of effect and understanding can be made of noise in these contexts? Here, we can return to Miller's (2023) work on the Nambiquara and the telecommunications networks that invade their territory and cosmology. According to the

author, the lines that cut through their space intensify the effect of evil spirits on members of the tribe, and these lines can be understood as an excess that disturbs a certain order. Reducing the community addressed by the author to a cybernetic system, this excess is a noise that intensifies certain effects present in Nambiquara cosmology and corporeality. If the traces of the white man's existence are garbage that harms the indigenous people, the arrow mentioned by Ricardo is counter-garbage, a noise generated by another noise.

Unlike the progressive aspirations that the arrival of submarine telegraph cables provoked, driving the end of slavery in Brazil, the arrival of cables in the interior of the territory brought with it a constant threat to Amerindian bodies and cosmologies. In fact, it can be argued that this infrastructure brings with it ideas of body and spatial organization so that it can operate in a capitalist regime. These ideas, of a liberal nature, presuppose free and rational subjects. This freedom is based on the premise that one must own one's own body. However, for this body to exist, all others must be abolished, as well as types of agencies outside of capitalist instrumental rationality.

The understanding of the relations between value and information has a notably pessimistic tone. It could not be otherwise, since up to this point in the chapter, the description and analysis of what my interlocutors shared does not stray from a logic of capital accumulation in the face of crises that emanate from the very work they perform every day. The next and final point of this chapter, proposes a line of flight on the relation between value and information.

Rubbish In The Machine

When asking Andrei how Peekaboo Telecom made money, I suggested that information was the raw material that they, in a somewhat alchemical way, transformed into value. He

disagreed with this hypothesis, and to support his argument, he presented a curious notion of value regarding information. For him, information has zero value. In other words, an idea that emerges from a human brain and is recorded on an artifact (be it a sheet of paper or a hard drive) has no intrinsic value. At the same time, according to Andrei, it has infinite potential value, as it can be a market game-changer. In this sense, the work done by him and his team is to make information flow smoothly and securely. The value of information, therefore, would not be represented by a half-line with a zero origin point, but would be a simultaneous, empty, and infinite state.

This type of account, part improvised cybernetic ontology, part professional experience from which he distills a fraction of an experimental political economy, left me perplexed and curious. This is because Andrei, an experienced CTO and professor of several classes in computer networks and related topics, has an intimacy with information that an anthropologist in the field rarely has, and the author of this thesis is no exception. It should also be noted that his discursive foray into information was made with much more enthusiasm than the somewhat mundane explanation of the work that generates value at Peekaboo Telecom. Thus, it is not a matter of interpreting the interlocutor's affections or speculating on intentions about what one prefers to say, but rather pointing out that he could have chosen safer paths, resorting, for example, to the authority of experience, to answer this question. However, he chose to say this, and I believe that this choice is symptomatic of the imaginaries and beliefs that underlie his actions. In other words, regardless of the “reality” of the definition he gave, exploring the elements that compose it in terms of value helps to understand part of his worldview about this socio-technical environment.

Andrei may have chosen the two worst values to assign to a commodity, since a business transaction can’t be done if its value is null or impossible to pay. More than that, these values

do not occupy polar positions on a gradient, but are in overlapping actualization. It is as if a data centre, in all its mundane character, were the place where values are magically transmuted. He mentions moments when this transmutation occurs, such as when the stored information is files to run on a killer app, or in the case of a doctoral thesis in anthropology that may become a prestigious book. In other words, his explanation lies in the type of intellectual property that can be reproduced (a book), or whose value lies in the adherence that users make of it (an app). Taking the examples at face value, the mystery would be solved. However, in an environment where profit depends on the control of obsessively measured and calculated variables, Andrei's conviction in zero and infinity is symptomatic.

Zero is not just any number. According to Rotman (1987), it is a meta-sign, since it indicates the absence of all other items belonging to the same subgroup. This mode of representation "allowed zero to serve as the site of an ambiguity between an empty character (whose covert mysterious quality survives in the connection between 'cyphers' and secret codes), and a character for emptiness, a symbol that signifies nothing" (13). In other words, it can be a number among other numbers, denoting, for example, quantities to the power of ten, as well as a sign that points to the absence of other signs that share the same nature (in the case of mathematics, a number indicating that there are no numbers). If we think about this ambiguity in terms of economic value, a commodity with zero value occupies a borderline position, as it can either be something with zero exchange value or be devoid of this attribute. Each of these possibilities has important consequences for thinking about them in the cybernetic-capitalist circuit of which information is a fundamental part.

A commodity without exchange value is a contradiction in terms, since it is this attribute that defines it as such. If a discrete piece of information (a file, an algorithm, documentation from a Python library) comprised only its use value, then its existence would be outside the logic

of capitalist accumulation. On the other hand, if there is a category of exchange value whose value is zero, then it is useless. The more the meanings of Andrei's zero unfold, the greater the strangeness, as it is as if data centres were places where piles of useless information were accumulated in the hope that a fraction of it would become desirable, profitable. In other words, the existence of “digital rubbish” is what drives the productive logic of which Andrei is a part. Rubbish is also an important conceptual element in outlining the logic encrypted in his explanation.

The disjunction between something that exists but is devoid of value can be understood, according to Michael Thompson (1979), as rubbish. The category of rubbish was conceived to deal with processes of value transfer between certain types of objects. Thompson thinks mainly about the transition of value and status in second-hand items, cultural artifacts, and real estate, so he proposes two initial categories to understand them: those that have infinite expected useful life and increasing value (durable, like a Queen Anne tallboy), and those that have decreasing value and useful life over time (transient, like a car). High-value objects are owned by people who, with social, political, and economic means, keep them increasing in value. In this way, durable and transient would be static positions of value that objects occupy. Instead, Thompson argues that there is a dynamic of value in which transient objects acquire value. This dynamic, in turn, depends on an intermediate state, rubbish, characterized as a limbo of value and time. It is in this limbo that changes in social trends can act to bring objects back into the durable category.

As a cultural anthropologist, Thompson limits his scope to things that are more tangible than information, such as furniture that becomes antique and degraded neighborhoods that become cultural heritage. More than that, his work seeks to challenge assumptions about ecology and economics, such as the “intrinsic” value of something based on its materiality, or the idea of

scarcity, which supposedly determines the valuation of goods, being common sense among certain types of economists. To support his argument, he explores cultural logics in different contexts that make valuation processes irreducible to the premises of economic science. In the context of data centres, information hoarded on servers, inert and of zero value, can be understood as “digital rubbish.” It is precisely its potential to become “infinitely valuable” that reiterates this category for Andrei's description.

And what would infinity be? One could take the term used by Andrei as hyperbole, interpreting it simply as a high or unknown value. However, instead of guessing what he “really” meant to express, it is preferable to take his choice of words seriously. As a concept situated at the intersection of philosophy and mathematics, infinity has been the subject of reflection from classical antiquity to contemporary thought, so that several thinkers have devoted themselves to it, such as Levinas and Heidegger, not to mention mathematicians such as Cantor and Dedekind, who inspired the author to be articulate in this part, Alain Badiou. This articulation, however, will not be based on an exegesis of the French philosopher's work, but mediated by the work of Alexander Galloway, a media and computing thinker. Thus, this reflection is not only theoretical or speculative, but engenders modes of politics and the constitution of subjectivity (Badiou), and cosmology and world order (Deleuze, Leibniz). Badiou (2008), for example, argues that numbers govern our economy and culture, inform our soul, and make up almost the entirety of the human sciences, justifying his project by stating that “we don't know what a number is, so we don't know what we are” (3). Although it is not intended to radically adopt an ontology of numbers for this thesis, data centres house essentially mathematical machines, and the economy surrounding them, as my interlocutors show, is made up of numbers.

A starting point for this incursion is the dichotomy between discrete numbers (which can only take integer values, and are therefore counted) and continuous numbers (which can be measured and therefore take an infinite number of values within an interval). These two modalities allow for different abstractions of the world. Continuous numbers, such as rational numbers, allow calculations such as integrals to be made. Discrete numbers, in turn, are the mathematical basis for computing, composing bits, data packets, and frames[22].

It is in this functional affinity that, by articulating Badiou's philosophical project with his work in computing, Alexander Galloway (2019) repositions this dichotomy in terms of digital and analog, so that analog thinking, continuity, and incommensurability refer, for example, to Deleuze and Guattari's rhizome and Spinoza's affect. Galloway attributes the digital to Leibniz and Democritus, who think about the world in terms of monads and atoms, respectively, that is, indivisible and discrete elements that form the basis of a cosmos.

More than modes of philosophy, analog and digital are ways of acting and conceptualizing the world, or, as Galloway states, “not just as two modes of mediation but as two varieties of difference” (97). Thus, differences in the digital do not have a gradation or intensity, as is the case in the analog, but are encoded by distinctions and oppositions with well-defined boundaries. The most obvious case is that of binary code, composed of the signs zero and one, but one can consider the letters of the alphabet and the tonal system in music as discrete modalities of human culture. This, however, does not imply a pessimistic conclusion of dehumanization or fetishization of the modern subject, since mathematics has always constituted Western human epistemology, either as a presupposition or as a means of overcoming it. It is discrete mathematics, according to Badiou, that offers fundamental

22 Here I anticipate the approach of Latour and Woolgar that will be developed in the following paragraphs on the construction of laws. In responding to an author who claims that “the tides would still turn and metals conduct electricity in the way that they do, without a Newton or a Drude to produce our knowledge of them,” Latour and Woolgar (1986) argue that taking such phenomena as given, external to scientific activity, implies ignoring the “concerted efforts toward the pursuit and revelation of the reality” (178)

categories for thinking about the world, from the One that attributes existence to something, to the intellectual processes of comparison and counting that allow the formation of the subject by establishing its relations and values with the world.

Badiou argues that the formation of the subject from a rational modality based on arithmetic, or what Galloway understands as the digital, reaches a turning point when dealing with infinity. The infinity of discrete numbers, such as natural numbers, where the next element is n + 1, is the result of a series of repetitive operations, in what Hegel (1969) qualifies as the "bad infinite." This modality of infinity operates as a stagnant hesitation on the logic of the formation of subjectivity, so that if this were the conclusion, infinity would be "merely the void in which the repetition of the finite operates" (Badiou 2005, 164), so that such infinity would result from a succession of finites. Or, according to Gérard Lebrun's depiction of capital: "a monstrous mixture of the good infinity and the bad infinity, the good infinity which creates its presuppositions and the conditions of its growth, the bad infinity which never ceases to surmount its crises, and which finds its limit in its own nature" (2004, 331). However, this is not the only type of infinity: when exploring the quantity of numbers in parts of sets with infinite elements, Cantor reaches an impasse when defining the cardinal position of an infinite element. In the void that opens up from this situation, "it is necessary to tolerate the almost complete arbitrariness of a choice, that quantity, the very paradigm of objectivity, leads to pure subjectivity" (Badiou 2005, 280). It is from choice that infinity can be multiple, and not from a mechanical monotony like Hegel's, thus paving the way for the emergence of subjectivity, and hence, of novelty.

Thus, the point is not to choose one infinity as "preferable" to another, but to understand the dynamics of each and how to articulate them. Following the intuition of Gérard Lebrun, one might say that the good infinity as articulated by capital implies the production of new means

of production and exploitation, each with its corresponding subject and its forms of struggle and resistance. The bad infinity, in turn, is the reiterated repetition not only of capital accumulation, but of the recursive repetition of labor as alienated activity.

Andrei's insistence on attributing “infinity” to the value of information places him at a crossroads between two infinities, each relating to a possibility for the value zero. If zero is the emptiness of the exchange value attribute, then information is rubbish in a state of latent valorization, and infinity is the potentiality of the repetition of valuation processes as a commodity. In this repetition, the oscillations of value as a magnitude can be understood as a bad infinity. Now, if zero was precisely the absence of exchange value, then the unfoldings of information qua value can’t succeed, as it would be outside the grammar of capital.

Which type of infinity did Andrei want to express? Or, even if we assume he doesn't really relate to the ideas and worldview of a French Maoist philosopher, which type would be closer to what he told me? Both questions are inappropriate, not so much because of the obvious, already failed, pretension of deciding on an intention of meaning on the part of my interlocutor, but above all because of the tension between these modalities, which, under the sign of value, frame information as what it is desired be (a commodity whose value variation is infinite, while at the same time, ideally, tending towards infinity) and what it can be (a pure use value, something alien to capitalist mode of production). Stripped of its exchange value, what can information be?

Conclusion: Information Matters

In his work on the cybernetic developments of late capitalism, Dyer-Witheford (2025) argues that “the ‘annihilation of space by time,’ (...) is intensified by production operations at the scale of the world market – and the whole ensemble is increasingly governed by the logics of

velocity" (13). In doing so, the author echoes an intuition already articulated by Hartmut Rosa (2010) regarding the contemporary process of acceleration both on capitalist exploitation and the subjective experience of time. Indeed, the acceleration of productive and cognitive processes promoted by digital technologies adds yet another dimension to the contradictions of the prevailing mode of production. Data centres, however, raise doubts about the primacy of time over space. While the experience of a Zoom session between a student in Brazil and a supervisor in Canada suggests a flattening of space through information flows traveling at near-light speed, the construction and maintenance of data centres are strongly dependent on space. The placement of CDNs—content delivery networks such as those used by streaming services—requires proximity to users in order to avoid latency (small yet perceptible delays in data transmission). Thus, even though these machines accelerate computation and data transmission, digital technologies cannot dispense with space. In this sense, space, as the medium of material existence, asserts itself as an obstacle to the intensification of modern capitalist temporality.

This premise makes it necessary to understand information as something material. Although relatively straightforward, this necessity arises in opposition to a common assumption of information's supposed immateriality, which lends it a form of environmental neutrality. Policies aimed at reducing paper usage in offices and universities, for example, often justify themselves by citing the reduction of tree cutting, implying that digital substitution is ecologically less costly. This immediate conclusion—saving trees and alleviating environmentally guilty consciences—only makes sense if information is imagined as being transmitted wirelessly, almost ethereally, without friction with the material dimension of the world. This magic of immateriality, in turn, is effective only when infrastructure performs one of its key feats: concealing its own operation, typically from those who depend on it. In

societies whose modes of production rely on the violent expropriation of land, resources, and life, infrastructure helps mask these processes.

This is the case with information infrastructures. Despite being separated by decades, the telegraph network installed by Rondon and the fiber-optic network maintained by one of my interlocutors share the same antagonistic relationship between nature and infrastructure. The implementation of the telegraph network across Brazilian territory brought with it cosmological and environmental disruptions that affected the existence of the Nambiquara people. In the case of fiber-optic cables, as described by my interlocutors, this relationship becomes reciprocal: if these infrastructures disrupt the spaces they occupy, the events produced by those spaces can also disrupt them. Once broken, these cables become compromised, forcing the replacement of their entire length and interrupting the flow of light beams—that is, information. This is particularly relevant in the context of mission-critical data centres (that is, the need for uninterrupted operation, to be explored in the next chapter).

If, as Leigh Star (1999) suggests, infrastructures become visible when they break down, events that disrupt their functioning provide opportunities to render them visible. The work of maintaining infrastructure, therefore, is not only about keeping it productive, but also about keeping it invisible. In this sense, if the work carried out in the contexts described by Ricardo and Thomas (forest), and Carlos (city), involved dealing with disturbances such as arrows, thieves, power outages, and storms, one may speculate whether the value generated by this labor lies in maintaining the nature–culture divide in terms of infrastructure and what lies outside it.

In terms of ecological preservation, one immediate consequence is that nature—inasmuch as it represents a risk to the functioning of information infrastructures—must be neutralized, even if this entails the destruction of ecosystems and the displacement or neutralization

(politically or biologically) of their inhabitants. Contradictorily, this is the price to be paid for reducing paper use in assignments and exams, among other ethical-technological advances celebrated in ESG reports.

The ecological issue, although urgent, is not the only one and, as I will argue in the final words of this chapter, not even the most profound. Carlos's professional context—the city—is equally relevant, even if it lacks the same environmental appeal. The security of infrastructural elements in urban environments deals with different types of disturbances, such as traffic accidents, theft, and vandalism. As part of the urban landscape, these infrastructures reinforce security dispositifs for maintaining private property, transforming spaces that could have aesthetic, political, and social potential for coexistence into mere supports for networks, servers, cables, and poles. Thus, maintenance work on this type of infrastructure consists in freezing its entropic process of decay. Entropy, as in thermodynamics and Wiener's cybernetics, represents the dissolution of order into chaos; maintenance work aims to preserve infrastructural order at the cost of neutralizing the possibility of emergence in its surroundings. As will be shown in the following chapters, the core functioning of data centres lies in producing value from the entropic relations within their technological ecosystem, which performs thermal exchanges between internal and external environments while maintaining computational labor in their servers.

Chapter 6 - Computation and/as Ecosystem

Introduction

The central topics of the last two chapters, energy and information, mirror two of the three aspects that my interlocutors claim to be the basic elements of a data centre, namely energy, connectivity, and cooling. Energy and information are also elements that, according to Gilbert Simondon (2013), result from the separation brought about by the industrial machine. Thus, according to the philosopher, "[t]he industrial modality appears when the source of information and the source of energy separate, namely when the human being is merely the source of information, and Nature is required to furnish the energy" (20). Considering that the Industrial Revolution was the material-technological manifestation of the capitalist regime, this separation can be understood as a process of the alienation of labor, reorganizing its division and automating both energetic and informational processes (Pasquinelli 2022), in order "to remove the 'human factor' and anthropomorphic skills from the act of interpreting a message" (16). If, with the tool, energy and information were an inseparable whole constituting labor, with the machine labor is not only split into two—energetic and informational—but also becomes automated.

Chapter 4 described the automation of energetic labor through the transformation of nature into a reservoir of potential labor. Chapter 5, in turn, showed how information networks made it possible to intensify both the maintenance of the Brazilian state's sovereignty over its territory and the emergence of new social configurations and conflicts. Above all, energy and information infrastructures do not exist apart from the environment, but with and against it. Thus, the primacy of these infrastructures over the existence of their users attests to

alienations of the following orders: first, the modern project of alienating the human from the non-human, also cynically (and naively, for those who ignore the climate crisis) understood as domination over nature; second, the capitalist project of alienating the human from their labor by transferring their skills to machinery in the form of energy and information.

Both energy production and the circulation of information presuppose a given ecosystem, which human interference modifies, generally violently, in order to make it part of the world-ecological regime (Moore 2015). This is not an ecological "end of history," but rather a stage in a conflictual process in which modern-capitalist agents maintain, repair, and upgrade their infrastructures at the same time that human and non-human agents external to this regime produce disturbances to them. This is the dynamic that Moore calls environment-making, "that encompass and are necessary to sustain a project of endless commodification" (87).

Whereas the previous chapters showed how this environment-making occurs in its extensive dimension, through the occupation of spaces aimed at their exploitation, this chapter shows how environment-making also occurs intensively, through the production of internal ecosystems of energetic, hydric, informational, thermal, and labor flows. In this way, energy and information meet again in this ecosystem for the activity that underpins it: computation. To this end, the chapter begins with a historical account of this activity, which, in different sociotechnical arrangements, has existed since the earliest iterations of capitalism—from the Jacquard loom to supercomputing infrastructures—finding in data centres its most notable example.

Computation and Its Ecosystems

Fieldwork revealed to me a somewhat ambiguous aspect of data centres: at the same time that my interlocutors claim that data centres are a business based on energy and real estate, the

advertising and expectations surrounding this infrastructure are strongly associated with cutting-edge digital technology, with AI being the dominant trend at the time of writing this thesis. This ambiguity is reinforced by a certain lack of interest on the part of my interlocutors in discussing digital technologies. In both public contexts and private conversations, AI is mentioned more as expectation and speculation (or "hype") than with the same level of detail and technicality with which cooling and energy are explained. In part, this is understandable, since what happens inside the servers is the responsibility of the data centres' clients.

If computation is an activity outside the immediate competencies of a data centre, the reader may wonder about the raison d'être of this chapter. Would it not be more pertinent, for instance, to address the environmental relations of these infrastructures? Certainly—and that is precisely what this chapter sets out to do. This will be done by taking computation as an activity that demands, and therefore produces, an environment. Such a proposition is not overly audacious, since different human activities require spaces with specific environments. A classroom, a shopping mall, and a football stadium have different architectural elements for, for example, regimes of visibility, forms of air circulation, and acoustic reverberation. Above all, they are designed for particular flows of objects and people.

Computers undergo a similar treatment, such that it is no coincidence that the technical field in which the ideal positioning of a computer's components is tested and studied is called computer architecture. Both the cases of personal computers and the flattened polygon that is a smartphone are calculated so that electrons pass through circuits efficiently, without their components melting or burning due to the heat generated in the process. These two examples are computing devices whose scale can be grasped with little effort by an individual. A personal computer is an object in a home or office, and the activities it enables are generally

oriented toward its user, such that responsibility for the necessary care and maintenance falls to them. If, as Paul Virilio (2005) argues, a new technology brings with it new possibilities of accident, one can infer that it also brings a set of sociotechnical arrangements to mitigate the likelihood of their occurrence. This is no different with computers, both in terms of this equipment as a domestic device and in its large-scale use for corporate or governmental purposes. However, between a domestic device and a computing infrastructure at scale, there is a qualitative leap.

It is within this chain of technologies and efficiency metrics that data centre managers make their decisions. Thus, if on the one hand energy and information entail different modes of destruction of non-human nature, on the other they engender relations of collaboration among the labor performed by non-humans which, after infrastructural reconfiguration, come to produce watts and circulate bits. The humans of these infrastructures, in turn, keep them operational and protected.

When asked about the type of mission-critical planning required for data centres, James, the CEO of an engineering firm specializing in this kind of project prefers to take a step back and explain what computers, the main inhabitants of a data centre, actually do. According to him, computers are simple machines because, at their core, they perform binary additions. The difference between machines with paper input and output and today's technology, still according to James, is a matter of scale. More powerful chips add faster, but they also produce more heat. Scaling up processing capacity leads to the emergence of new types of risk to the operation of servers and the systems that house them. Conversely, modes of sensing these spaces also increase—what James calls the environment. Between this trajectory, summarized in this paragraph, and the use of ecological terms such as environment

and inhabitant, this chapter will outline ecological and computational aspects that have affected these machines and the spaces that house them since their earliest iterations.

To understand what James told me, a brief foray into the history of computing will be undertaken. The discussion thus begins in the twentieth century, emphasizing developments that occurred in capitalist countries and, when necessary, addressing the efforts Brazil made to integrate computers into its governmental practices. This framing leaves out artifacts such as the abacus and Babbage and Lovelace's Difference and Analytical Engines, which in themselves already evoke reflections on the formalization of the world into numbers, formal logic, and discrete particles. In doing so, the emphasis is placed on the idea that technical objects do not, by themselves, produce social change or revolutions, but rather accelerate ongoing processes and open up possibilities for exploitation and resistance that were not foreseen prior to their implementation. In this sense, one can say that the context of the Second World War and its aftermath are marked by the encounter between a computational logic gaining strength with Claude Shannon and Norbert Wiener and a manufacturing industry at the height of Fordism.

The "invention" of the computer was not a single historical and geographical event, but a process permeated by limitations, failures, and assemblages of technological artifacts that stabilized around particular use cases. Thus, one may mention the Z1, produced in Germany in 1936, and the ENIAC, begun in the United States in 1943. Although these machines performed mathematical calculations and logical operations like any computer, they still differed from contemporary computers in the kind of materiality that gave form to their components: they were composed of valves, that is, vacuum tubes that conducted electrical voltage through a circuit of cathode and anode separated by a control grid. They were already voracious consumers of energy, requiring between 140 and 174 kilowatts for hundreds of

operations per second. By way of comparison, contemporary supercomputers operate at a rate of 6,673.8 million operations per watt.

Curiously, when compared with the thermodynamics of contemporary computers, the flow of electrical voltage was intensified by heating the cathode (the metal filament at the centre of the cathode), such that heat was a requirement for processing rather than merely its by-product (Rojas and Hashagen 2000, 177). Another implicit but important aspect to highlight is that this involved only a single processing unit (that is, one computer) occupying an entire floor or building, relying on varied techniques for heat dissipation, rather than a standardized, scalable infrastructure.

As already mentioned, the first modern computers began to emerge in the context of the Second World War, representing a cybernetic transformation of the war machines of the powers involved in the conflict. In other words, just as important as the effectiveness of the logistical, tactical, and strategic aspects of the battlefield was the need to understand them as information to be processed in terms of control and statistics. As shown in the chapter on information, this shift was already an ongoing process prior to modern computers, such that these machines, as will be shown, merely accelerated processing capacity and facilitated the decoding of the world into binary code.

As part of the military-industrial complex, these computers were operated through cooperation between universities and departments related to war and security, performing calculations related to ballistics, cryptanalysis, and the development of the atomic bomb. It is in this context that the notion of a “bug” began to circulate within computing, a term that today is commonly used to refer to a programming problem in software. Grace Hopper, a prominent computer scientist in the U.S. Navy, recounts that a moth was found in the Harvard Mark II computer in Cambridge, Massachusetts. The machine had stopped

unexpectedly, and upon inspection, an actual insect—a moth—was discovered lodged in a valve, causing the computer to malfunction and cease operation (Cardi 2002; Kidwell 1998). This terminology, however, had already been used in electrical engineering prior to that episode, as in the case of Thomas Edison, who described such issues as things that "gave out," requiring effort to overcome them (Wills 2019).

This context thus highlights two movements in the relation between computation and the environment. On the one hand, both literally and metaphorically, this relation takes place within the environment as a site of potential disruption to computational infrastructure. An unexpected event—whether an insect invading an electrical circuit or a power surge—is a form of material agency that lies outside Western instrumental rationality. The other movement concerns the growing prominence of information, which ceases to be merely a means for warfare and becomes an end in itself, given the importance of code-breaking, spy satellites, simulations, and "war games" (Ceruzzi 2003). In other words, information becomes simultaneously something to be produced, processed, and communicated, as well as a dimension within which human activities, such as war, unfold.

A key moment marking the beginning of the proliferation of computers beyond the academic-military environment was the invention of the transistor. Early transistorized machines, such as the TRADIC from Bell Telephone Laboratories, consumed significantly less power—only 100 watts—a stark contrast to the kilowatts used by their valve-based predecessors. This reduction in power consumption also meant that components could be placed closer together, increasing speed and reducing the need for large air-conditioning installations. In this way, there was a spatial densification in the organization of computational components, alongside a reduction in energy cost per operation. Beyond the miniaturization of these components, their mass production made computers accessible to private enterprises, especially in the

form of mainframes—computers that process batches of information for accounting, human resources, inventory, and other data-processing tasks.

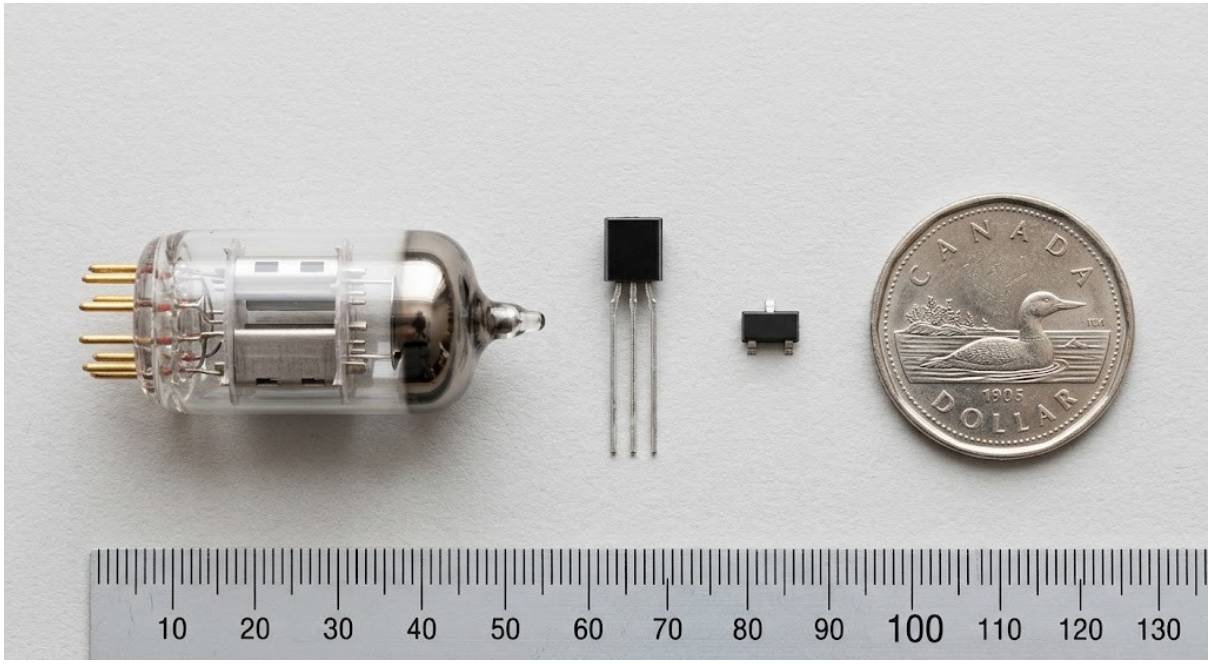


Figure 10. Left to right: a 12AX7 vacuum tube (~45 mm), a TO-92 transistor (~5 mm), an SOT-23 transistor (~3 mm), and a Canadian one-dollar coin for scale. One tube occupies the volume of roughly 4,000 SOT-23 transistors. ENIAC (1945) spread ~17,500 tubes over ~167 m² to perform ~5,000 operations per second. An NVIDIA H100 fits ~80 billion transistors on 814 mm² and delivers ~67 TFLOPS (FP32): about 200,000 times less area for roughly ten billion times more operations per second. Image created by Google Gemini AI.

Mainframes can be understood as an embryonic form of data centres, since both their use and the spaces produced to house them share important similarities. In addition to the aforementioned commercial purposes, their installation required a specific space, with a false floor raised above the actual ground level. This void was reserved for cable connections and the circulation of air conditioning (Ceruzzi 2003), recalling the spatial organization I observed in Unicorn Data Centres facilities. Another notable aspect of these machines was the business model of which they were a part: in the 1960s, renting a mainframe cost around

US$30,000 per month, creating a strong incentive never to leave a machine idle. The articulation between this machine and IBM's business model—the company that commercialized it—made computation a productive process that equated time, money, and energy as scarce resources.

The process of component miniaturization intensified with the advent of integrated circuits, or what are now commonly known as "chips." These artifacts involved encapsulating multiple electronic components—such as transistors, resistors, and capacitors—onto a single, small silicon wafer. This rapid advancement made machines smaller, more powerful, and significantly cheaper, fueling the microelectronics industry. In contrast to transistors, which required labor-intensive hand-wiring, the advent of photolithography—that is, the process of coating semiconductor substrates with photosensitive films (photoresists) and selectively irradiating them with an aerial image of the circuit design features (Wynand et al. 2018)—enabled integrated circuits to be mass-produced using photographic and etching techniques, making them inexpensive, fast, reliable, and rugged, much like printing a paperback book (Ceruzzi 2003). Photolithography itself, however, required a highly controlled environment in order to function. It is therefore in this manufacturing process that one can observe the production of an environment which, oriented toward the exploitation of labor, creates conditions for the well-being of integrated circuits at the expense of the people and environments that preceded these factories.

As Gabrys (2011) describes, chip production environments depend on atmospheres free of dust and other particles, such that workers involved in the physicochemical processes of production wear specialized insulating garments. At the same time, 99 percent of the materials used are discarded. It is noteworthy that these garments are not intended to protect workers from the chemicals used in silicon processing, but rather to protect the chips from the

workers' bodies. As Gabrys also points out, these manufacturing plants were established with government incentives, including tax exemptions and lax oversight of the disposal of toxic by-products. The consequence was the contamination of surrounding regions, affecting workers—mostly racialized women—and their children.

Still focusing on the workers in this sector, Nakamura (2014) shows how Navajo women were hired by a prominent chip manufacturer at the time, Fairchild, on the basis of racial and gender stereotypes that cast them as possessing "nimble fingers," as well as a temperament and culture supposedly suited to the production of these artifacts. According to the company's discourse, these attributes were evident in the weaving work these women performed, demonstrating a natural affinity for becoming this type of proletarian. In this way, the "modernization" of this tribe through its integration into contemporary capitalism occurred not only through fiscal incentives and postcolonial relations, but also through discourses that legitimized this new phase of exploitation—discourses endorsed even by the leader of the Navajo Nation at the time.

The proliferation of chips, as Gabrys (2011) argues, did not occur in response to a preexisting public need that these artifacts could fulfill. Rather, demand had to be created so that Fairchild could offset military cuts in electronic research spending. To this end, the company organized its production by prioritizing the quantity sold to the market, even if the profit per unit was initially lower. With the absorption of chips into household appliances, the expectation was that consumer demand would emerge through the pervasiveness of this new technology. This intuition proved correct, and Gordon Moore—the author of the law predicting growth in processing capacity every 18 or 24 months—referred to this achievement as an invention (Berlin 2005), which Gabrys (2011) characterizes as "a

technology in the form of markets" (30). This makes clear that technology does not have a telos separate from other human spheres, but is co-produced with them.

This history, which intertwines gender, race, pollution, and markets, is important because it marks the moment when digital technologies began to infiltrate everyday life—both in computers that would become tools in offices and in the control of household appliances and other everyday devices. More than that, the analyses by Nakamura and Gabrys show how a microchip is a technology with an end in itself (to compute), but also a technology that produces an image of a proletariat emerging from the remnants of colonial violence, forming wasted lives "whose destruction transfers value and which are agents of history by their very demise" (Kadri 2023, 80). These facts help to dismantle the imaginary that digital technologies are intrinsically the key to human progress and to mitigating environmental degradation, when in fact, like any industry, they consume and degrade both humans and the environment.

By the mid-1960s, the economic viability and pervasiveness of microchips consolidated this artifact as a ubiquitous item across multiple dimensions of modern life, from household appliances to infrastructural control systems. Moreover, computers became part of office work, as in financial transactions, telephone switching, and computer-aided design. In this context, technology companies continued to invest in innovations aimed at increasing processing capacity and reducing manufacturing costs, resulting in the advent of the microprocessor. This made it possible to integrate all the components of the central processing unit onto a single silicon chip, such that processor speeds, memory, and transmission rates have been increasing 60% per year. Previously, because these components were separate, computers had limited commercial appeal in terms of both performance and cost. Above all, it was within this new component architecture that the personal computer

was developed, disseminating human–machine relations into social spheres beyond the scientific domain.

The performance increase mentioned above was proposed by Gordon Moore, making this growth rate a law bearing his name. Laws, in turn, have the performative potential to circumscribe a reality in the terms they articulate. This is the case both for the laws of physics, which determine the variables that constitute a phenomenon and its effects[23], and for legal laws, which establish bodies, prohibitions, and penalties.

It is therefore necessary to explain in greater detail what Moore's Law is. It was not produced in a laboratory, but emerged after the publication of "Cramming more components onto integrated circuits" (1965), in which Moore celebrates the technical breakthroughs that made possible a synergy between the cost of integrated circuits, their processing capability, and their performance per watt. Thus, thanks to the increasing miniaturization of transistors, the more components that could be coupled onto a circuit, the lower the relative cost of processing capacity. This would result in Moore's famous estimate that the number of transistors on an integrated circuit could double approximately every year and a half.

The most evident consequence of this law is that it enabled predictability regarding the increase in computational capacity relative to the size of integrated circuits, allowing for the planning of new models and, consequently, the scaling of activities dependent on computation. The less evident consequence—despite being under the nose when observing Moore's Law—is the Jevons Paradox, now in its digital version. If computational capacity increases as transistors shrink, what are the economic incentives for the ever-growing

23 Perhaps the origin or authorship of the voice that emerges in a reading matters less than the effects it produces on the reader. In Michael Cisco's fiction *Animal Money* (2015), one of the characters offers the following reflection: "A whale, plunging into icy darkness and pressure, listening as the echoes of its own voice tell what's all around it. (...) That echo returns a new voice. New to you, although it's your own voice, calling to you from just around the corner of a moment ago." (Part Three - Nonsmoking Smokers).The whale's voice produces its perception of space, situating it in relation to other whales, animals, and objects. The voice of reading produces the space of perception, of what may emerge as a possibility of the sensible within a text.

production and consumption of computational devices? What kind of tendency is this, in which a society that consumes digital technology aligns its appetite for computation with the pace of performance growth of these artifacts? Returning to the article by Pasquinelli (2022) that opens this chapter, one of his central arguments is that the metric of what a machine is capable of producing represents a sign of equivalence with human labor, allowing capitalists to control and negotiate its value. Thus, according to Pasquinelli, energy was the metric that made it possible to equate machine labor with human manual labor, while information did the same for mental labor. Information therefore becomes a constitutive element of labor, such that "the factory's management and bureaucracy monopolise control information to govern the production process as a whole and ultimately labour power" (21).

In this sense, for Pasquinelli, "[w]hat information measures and mediates here between workers and capital is clearly intelligence, knowledge, the know-how of the production process" (21). Without disputing that information can be a measure of intelligence and knowledge, it will be argued here that information is not the metric of mental labor, but rather computation. The very terminology of units of measurement between energy and information implies a fundamental distinction: whereas the joule per second implies a process of transfer or consumption, digital information is expressed in a single term, the bit. This means that it is a fixed sign or material, possessing the potential to be interpreted or processed, much like a word that does not convey its meaning on its own but must be read by someone. Thus, if the watt measures an amount of work over a unit of time—making the productivity of a worker comparable to that of a machine—the equivalent in informational terms is floating-point operations per second (or millions of instructions per second, depending on the type of computer architecture).

The type of human labor over which the metric of computation allows capitalist control and negotiation encompasses mathematical operations, beginning with calculators that absorb part of the abstracting capacity of an engineer or a supermarket cashier and, at the time of writing this thesis, culminating in the automation and inference of statistical patterns for the synthesis of textual, audiovisual, and image-based material—artificial intelligence. Thus, returning to the less evident effects of Moore's Law, one can say that it laid the foundations for the pace at which different capacities of the modern subject's thought could be absorbed.

Even though it does not possess the scientific rigor of a law of gravity nor is it supported by a legal apparatus, Moore's Law was important in articulating the sociotechnical developments that enabled the manufacture of integrated circuits with their economic viability, and for a long time it served as a reference point in the cycle of processor innovation. Above all, as previously noted, the microprocessor represents a tipping point in computing as a commodity disseminated to the general public, paving the way for the symbiotic–parasitic relationship we have with digital technologies today. It is therefore necessary to explain Moore's Law in order to understand the factors that led it to stabilize in common discourse—such as in Huskey's account—but also how it itself affected the logic of innovation and microelectronics production at the time.

According to Latour and Woolgar (1986), laws are not "discoveries" of natural dynamics, but artifacts stabilized through the assemblage of institutions, tools, and actors with circumscribed interests in specific historical contexts. In other words, Latour is critical of what he calls a "realist" stance, which falls into a tautology by referring to natural phenomena as existing in and of themselves, but only insofar as they are described through an articulation of epistemologies, instruments, and institutions that delimit a given phenomenon. Against this blind spot of a supposedly neutral science that claims to unveil the secrets of nature, his

proposal is to understand the construction of scientific facts through processes of purification and stabilization of artifacts. These, in turn, are material and discursive arrangements that acquire the consistency of truth through cooperation and dispute among peers, the erasure of alternative procedural narratives within the laboratory, and the possibility of reproducing the artifact in other locations equally equipped with the necessary tools and forms of knowledge —in other words, they depend on specific practices and materialities.

Between Moore's publication and its transformation into a "law," there was a series of distortions and adjustments that turned it into a belief within the microelectronics industry. One of the earliest instances in which it was explicitly referred to as a law occurred in a 1977 article in *Scientific American* written by Moore's Fairchild colleague, Robert Noyce. Although there exists a dynamic within corporate and innovation culture that exceeds the scope of this research, it is worth noting that its elevation to the status of a law made it more than a mere observation or recommendation for the industry. Donald MacKenzie (1996), for example, understands Moore's Law as a "self-fulfilling prophecy" that denotes a certain autonomy from the social relations that brought it into being. Such autonomy, grounded in a feedback loop between technological progress and profit, is analyzed by MacKenzie through both a Marxist framework—used to examine the social relations of production of which Fairchild was a part—and a nod to actor-network theory, when he states that "the characteristics of the material world, of Callon and Latour's 'nonhuman actors,' play a part in determining the patterns that do become institutionalized" (58).

As one interlocutor who works on high-performance computing projects stated, today Moore's Law no longer exerts the same influence on projections and limits of computation. According to him, concerns about the environmental cost of computing and architectures that dispense with this law make it less dominant than it was during the period of integrated-

circuit innovation. Thus, one might say that it reveals itself in its illocutionary dimension—that is, by bringing a reality into existence while supposedly merely describing it. A complementary way of understanding this is through a reference Latour and Woolgar make to Marx, when they argue that "the construction of reality should not be itself reified" (1986, 179). For both the French sociologists and the German philosopher, the pursuit of objective truth and the scientific search for immutable laws are ways of erasing the practices that produce truths and laws. These practices, in turn, unfold through both social relations and material assemblages that enable particular ways of life, production, and determinations of what is possible and impossible. Indeed, it is impossible to think of social relations apart from the materiality that sustains them, and vice versa.

Between the mass production of integrated circuits and the contemporary proliferation of ubiquitous computing devices, there were different organizational forms of clusters for information processing. James, the CEO of a mission-critical engineering firm, told me that he has worked with data centres for at least 30 years. Part of his experience involved rooms with mainframes and computers that printed calculation results being described as data centres, such that—at least informally—"data centre" encompasses modes of computational concentration at scales and scopes different from those of the sites I visited during fieldwork. Nonetheless, all these cases share the production of an environment to deal with mission-critical operations.

Thus, unlike the technological developments discussed so far, it is not possible to precisely identify the "first" data centre, since buildings containing (and, in a sense, being) computers could already describe one of the earliest computers, the ENIAC, mentioned at the beginning of the chapter. Another moment of proliferation of this type of space occurred during the dot-com bubble at the end of the twentieth century, when data centres housed servers aimed at

improving internet service connectivity. As a milestone for the contemporary idea of data centres, this discussion takes an influential publication by Barroso and Hölzle, *The Datacenter as a Computer* (2009). This work discusses design properties of data centres that help to elucidate the contemporary paradigm of this infrastructure.

> The central idea is that the datacentre must be designed and treated as a single massive computer—the Warehouse-Scale Computer (WSC). This perspective is a dramatic departure from viewing the computing problem as a single program running on a single machine. The defining feature of a WSC is the massive scale of its hardware platform, software infrastructure, and data repositories. The hardware often consists of thousands of individual computing nodes with extensive cooling and power systems, enclosed in a structure often resembling a large warehouse. Moreover, WSCs are not simply a miscellaneous collection of machines co-located in a facility, but they require a holistic design approach where large portions of the hardware and software resources must work in concert to efficiently deliver performance for Internet services.

The formalization of data centre organization proposed by Barroso and Hölzle thus represents a qualitative leap in how large-scale computing is organized. The proposed organization to achieve energy and cooling efficiency focuses on both the facility infrastructure (measured by Power Usage Effectiveness, or PUE[24]) and the IT equipment itself (measured by Server PUE, or SPUE). The pursuit of efficiency as metrified by PUE implies modes of rationalizing heat flow. To this end, Barroso and Hölzle mention architectures and equipment that create corridors separating hot and cold airflows, water-circulation coils that cool the air from fans positioned against them, and free-cooling schemes that take advantage of colder, drier

24 A Distributed Denial-of-Service (DDoS) attack is a malicious attempt to disrupt a server, website, or network by flooding it with large volumes of artificial traffic originating from multiple compromised devices, commonly known as a botnet. This overload can slow down services or render them entirely inaccessible to legitimate users, and is often employed to interrupt operations or coerce targets through extortion.

climates (Barroso and Hölzle 2009, 42–43). They also propose the use of a raised-floor setup —common in data centres and present in the data centre of one of the interviewees—where CRAC (computer room air conditioning) units inject cold air into the plenum beneath the floor.

The production of forms such as coils and corridors, and of spaces such as the plenum of a raised floor, are elements of an internal environment of a data centre in which heat flows, once controlled, "work" toward the efficient productivity of the equipment. This environment, unlike the free and emergent flows of a river's currents or atmospheric circulation, is measured, parameterized, and circumscribed to precise spaces within a data centre. This material arrangement aims at the fine-tuning of heat flows, such that the effectiveness of maintaining an optimal temperature for equipment performance depends on how the equipment is installed, how much heat it produces, and the capacity of cold air delivery reaching it; a mismatch among these variables can have adverse effects on achieving an appropriate PUE. The management of hot and cold airflow, for example, depends on the arrangement of servers within a rack and their energy-thermal capacity, such that an insufficient supply of cold air may result in a situation where "all the cool air will be sucked in by some of the servers on the bottom of the rack, and the servers at the top will instead suck in warm air from above the rack," that is, "recirculation" (44).

Thus, careful airflow management is critical to prevent warm exhaust from mixing with cool intake air, which reduces cooling efficiency. To maximize efficiency, airflow from perforated tiles must match the horizontal airflow of servers to avoid warm air being drawn into higher servers. Newer designs physically separate hot aisles to eliminate recirculation entirely. Finally, facility energy efficiency can be substantially improved by allowing cold-aisle temperatures to rise to 25–27°C instead of the traditional 20°C setting (50).

Barroso and Hölzle's contribution was made at a moment when the then–Google Inc.—the company where the researchers worked while writing *The Datacenter as a Computer*—was coming to dominate the digital world, both through online commerce services and through geolocation services, academic social networking, book digitization, natural language processing services, and, ultimately, artificial intelligence. The expansion of services demanded increased computational capacity, which in turn required an environment capable of extracting value from equipment by making it operate through efficient energy use. It is worth recalling that alongside Alphabet (current Google's parent company), other firms developed their own strategies and bets on data centre implementation, such as Amazon, which now operates AWS cloud computing services, and Walmart.

By addressing computation both in the manufacture of devices such as integrated circuits and in the spaces where they are deployed, this discussion sought to move away from the misleadingly ethereal character that data centres acquire when referred to as the "cloud" (Mosco 2014). They possess a pernicious materiality for both humans and non-humans, such that their deleterious environmental effects can be understood as a capitalist form of environment-making (Moore 2015). Accordingly, the cases discussed thus far show that thinking about computation apart from the environment is equivalent to thinking about commodities apart from labor. Digital technology does not operate solely through its materiality and the systems and infrastructures of which it is a part; it also depends on elements whose existence presupposes sociotechnical assemblages, such as dust, the molecules that compose the atmosphere, as well as the energy and heat that emanate from and are conducted by them. Whereas in an external environment these elements behave in emergent and probabilistic ways, digital equipment demands the domestication of these particles and their energetic potentials in order to control them and produce value from them.

In this sense, while Ensmenger (2018) shows that computing has an environmental history with ecologies external to its infrastructures—such that the industry erases "both its own past and its connections to the material world" (26)—the remainder of this chapter proposes to understand how the internal dimensions of a data centre constitute an environment in their own terms. Thus, inspired by Taylor (2019), the ethnographic analysis that follows explores my interlocutors' accounts and the internal spaces of the data centres visited as elements of a technological wilderness.

Manufacturing Climate

The first half of the chapter showed that computation entails an environment suited to its capacity and scope. Even ancillary activities to computation, such as the manufacturing of devices at Fairchild, constitute cases of environment-making whose goal is to preserve the integrity of the commodities produced, even at the expense of the well-being of those who produced them. This, however, is not mere pettiness or commodity fetishism, but a condition for these technologies to function. Thus, digital technology depends on certain forms of care and calibration in order to operate. This necessity, in turn, cannot be explained solely by the material affordances of the technology, but is traversed by gendered and racialized issues, as Nakamura (2014) has shown, as well as by the capitalist telos of value production that underlies the idea of efficiency. The remainder of the chapter will show how my interlocutors maintain and justify the data centre environments of which they are part.

Before beginning the account of my visit to Peekaboo Telecom, it is important to offer a terminological clarification. The attentive reader may have noticed that the beginning of the chapter employs the notion of an "ecosystem" in relation to computing. As the chapter progresses, however, this notion appears to give way to that of "environment," without the

transition being conceptually delineated. This is not a terminological slip, but rather an effort to reinforce the distinction between two different ways of conceiving space. Environment can be understood as a field of conditions, or a space encompassing beings, atmospheres, affordances, and constraints, but not as a container that passively holds discrete objects. In this sense, environment is less a bounded space and more a relational medium within which life unfolds, or even a structured field of possibilities for action. Ecosystem, in its turn shifts the analytical focus toward relations among beings. It foregrounds the agencies involved and the interactions through which an environment is composed and maintained. If environment is the field, ecosystem is the process of composition within that field. The concept of ecosystem thus places equal emphasis on organisms, infrastructures, materials, and the interactions: metabolic, energetic, informational, and, in the case of the following field account, the electronic devices that regulate the environment.

On my first visit to Peekaboo Telecom's data centre, Carlos showed me the facilities with pride. It was a room relatively smaller than those of hyperscale data centres, such as the one I visited at Unicorn Data Centres. This, however, was not detrimental to the presentation, but rather a strategic asset that, according to him, allowed for the design of details that his competitors lacked. The first aspect he showed me was the electrical installation scheme. Unlike my visit to Unicorn Data Centres, no imposing and austere equipment such as Uninterruptible Power Supplies (UPS)—responsible for maintaining continuous power during outages or fluctuations—or PDUs, which distribute power from the UPS to the racks, were presented. Instead, he focused on the cabling used for power supply and on safety measures against phenomena emergent from electricity itself. He began by showing me metal bars flush with the floor, approximately 30 centimeters above ground, attached to metal supports and grounded. These were bare copper connections, coated with silver nitrate to

prevent oxidation and poor contact. This setup, according to him, creates a Faraday cage[25], which, together with the antistatic floor and the grounding mesh (itself connected to various elements of the space, such as windows and racks), protects the room from electric and electromagnetic fields. One of the phenomena emphasized by Carlos was arc flash, a violent electrical discharge that can form in a dry atmosphere without proper grounding. He then showed me the batteries, which, cooled by air-conditioning ducts, have their temperature and humidity controlled, thus extending their lifespan and ensuring proper discharge.

Electrostatic risk does not reside solely in managing electrical flow and insulating equipment internally, but also in the atmospheric conditions inside the room. It was with this premise that Carlos continued presenting the site, now focusing on the cooling system. This was another achievement in which he took great pride, because, according to him, the arrangement he devised between the air-cooling machines and the ducts connecting them to the hot and cold aisles was not only unique but also maximized the cooling machines' potential. In fact, Carlos claims that the level of optimization was such that the company that sold the cooling equipment became interested in visiting Peekaboo Telecom's facilities. The air-conditioning system thus operates in a dynamic and economical manner. The air emitted by the machines is channeled through ducts whose material and design, again according to Carlos, were low-cost and highly effective. The equipment begins injecting cold air when the temperature in the hot aisle reaches 27°C and returns to simple ventilation mode (without active cooling) when the temperature drops to 26.5°C, thereby saving energy. These numbers were not merely reported to me by Carlos but were measured by fixed sensors on the racks and displayed in an application that monitors this and other variables.

25 In compliance with the requirements of the Research Ethics Board, the names of the interviewees and the companies I visited have been changed to preserve their identities.

Carlos also devoted time to explaining the issue of humidity in the data centre environment. Conventional air conditioning is designed for latent heat (heat with humidity, such as human perspiration) and not for the dry heat produced by servers. On my previous visit to a data centre, Unicorn Data Centres employees told me that overly dry air could cause drying and cracking in server circuits and other equipment. I mentioned this to Carlos, but for him the real risk of dry air is that it creates an environment conducive to electrostatic energy, which can cause failures and burn equipment. Thus, relative humidity is controlled individually by rack and monitored in real time by the client. Peekaboo Telecom's goal is to maintain relative humidity at 50%, with an acceptable variation between 40% and 70%.

Indeed, Peekaboo Telecom's application is another interesting aspect, not only as a source of wonder for Carlos and his clients, but also for what matters to this research. It is an application that monitors a multitude of data centre states. To mention a few: the time a rack door is opened and closed, the air humidity near a server, the temperature emitted by a piece of equipment, and its energy consumption. Each piece of equipment is registered with a photo, model, owner, among other data, and has a QR code that allows these details to be accessed. The goal is to record any events of affectation, agency, or handling of technological objects, molecular flows, and human labor. Events that exceed a threshold of normality (for example, a rack door left open for too long during maintenance) trigger an alert for both the client and Peekaboo Telecom, allowing a diagnosis of what occurred to be derived from the information produced by the sensors and made available through the application.

The first impression one gets from this system is that sensors and the application turn the data centre into a space of surveillance. This is as correct as it is trivial, since it is to be expected that Peekaboo Telecom and any other data centre would have cameras and countless devices monitoring the variables they aim to control. One could also raise a political question

grounded in a Foucauldian critique of the micropolitics exerted over a worker's body—for instance, a technician performing maintenance or upgrading a rack. In this sense, such granular tracking would be nothing more than an update of the panopticon, whereby vision ceases to be central or radial and instead disperses across a multitude of devices, making the ecosystem both an actor and an object of surveillance. Air, invisible to the human eye, is revealed in its humidity and heat by sensors, while a door betrays itself through its opening and closing. In this way, surveillance in data centres flattens differences among their various elements, whether technological artifacts such as servers and doors, "natural" elements such as air, or humans, such as the few workers who keep the facility running.

"Surveillance," however, is a notion that, while helpful for thinking about the data centre in terms of continuity with spaces of digital value production such as Fairchild's integrated circuits manufacturer, as described earlier in this chapter, has limitations precisely when considering the type of value and labor constitutive of this space. A production manager coordinating the work of Navajo manufacturing workers, for instance, is interested in monitoring their performance in chip production. Such vigilance is even more important given that this is a collective work environment, in which any trace of sociality can pose a risk to the maintenance of surplus-value extraction. This visual topology and hierarchy of labor is nothing more than a late-capitalist iteration of the disciplinary model outlined by Foucault (1991), whose versatility—dispensing with the use of force—made it possible "to constrain the convict to good behaviour, the madman to calm, the worker to work, the schoolboy to application, the patient to the observation of the regulations" (202), no differently than in a Fairchild factory.

Needless to say, in data centres the control over the people who circulate within them is paramount, and this became clear in Chapter 3, where I describe my visits. Indeed, when I

visited Peekaboo Telecom for the second time, Carlos showed me an innovation in his application: not only were the opening and closing of rack doors recorded, but the doors now also had cameras that filmed the face of the person who opened them. I asked him the reason for this upgrade, since entering the data centre was already no trivial matter. He replied that this way the client would have more control over who was handling their equipment. This answer struck me as vague and redundant, and perhaps my question was ill-posed. But it is precisely the ill-posed nature of the question that allows one to distinguish a data centre like Peekaboo Telecom's from other spaces of computational production.

Setting aside specific measures, data centres and prisons have similar architectures. While the former have cells that condition people's entry, the latter have cells that condition their exit. Moreover, if one focuses solely on an architecture of enclosure and surveillance, these cells presuppose productive bodies—either in the making, as in rehabilitating the prisoner or training the student, or at their full potential, as with the data centre technician. However, the purpose of an institution and its spatial organization do not determine its procedures and processes; rather, they mutually condition one another, even if vectors of monitoring and spaces of enclosure remain predominant. This becomes clearer in the changing character of prisons across different technological implementations. In their analysis of the Swedish prison system, Anne Kaun and Fredrik Stiernstedt (2023) show how this type of institution is a site for experimentation with technologies aimed at new modes of control over inmates. These innovations, while maintaining the scope of treating the prisoner as an object of intervention and control, alter the dynamics of surveillance and, consequently, the very management of surveillance vectors, bodily flows, and the nature of activities conducted in this ecosystem. Thus, from a form of management "through which incarcerated individuals could be seen, heard, and registered at all times," the prison space came to be conceived as

“an architecture that enhances and creates communication both as movement and as interaction for the incarcerated individuals” (107).

A project aimed at the enhancement and creation of communication presupposes that information becomes the primary aspect of that ecosystem, such that the body and the subjectivation to which it is subjected lose centrality. This does not mean that the Benthamite model of the panopticon was not a media architecture, since it produced not only disciplined subjectivities but, above all, knowledge about behavioral techniques and modes of docilization. What changes with digital technologies in carceral contexts is the reordering of this architecture beyond the physical division of cells and bodies, expanding to prisoners’ movements inside and outside the prison through ankle monitors, to the images produced of them, and to their uses of communication devices. The fluidity of this set of techniques—softer and more effective than previous paradigms (which, it bears recalling, still exist in the world, just as modes of punishment and expiation remain resources in modern states)—allows for the control of dynamic variables with complex relations.

It is precisely this set of sensing techniques that makes data centres spaces in which processes of control and monitoring occur with the same subtle and soft character as the contemporary carceral paradigms addressed by Kaun and Stiernstedt. However, Carlos’s employees and those of the companies that operate their equipment at Peekaboo Telecom are not inmates. They work, at least formally, of their own free will. And yet, they are subjected to modes of surveillance and control. Adding to this strangeness is the fact that the scope of mission-critical operations implies, as mentioned in Chapter 3, the training of professionals and the composition of teams whose strict execution of procedures—especially in moments of crisis—leaves little room for procedural deviation, making the hypothesis of surveillance as a

coercive instrument over employees rather implausible. So how can this excess of apparatuses be explained?

To answer this question, I return to a presentation given by a director of a GPU manufacturer at DCD Connect. According to him, the planning of the company's office construction involved a simulation aided by artificial intelligence powered by the very GPUs the company produces. This simulation made it possible to calculate the incidence of sunlight on the floor plan, among other variables that would help engineers plan the future building. If an AI powered by GPUs was used, it follows that the model employed was trained on data that had been collected and classified so that the AI's algorithms could learn and form inferences on their own. Indeed, this is one of AI's trump cards as a promising platform for future business (even if, at the time of writing this thesis, it remains strictly speculative): it transforms data into a multitude of products.

Bringing artificial intelligence into the discussion would be an obvious answer, particularly in recent years, when its impact and allure have captivated people across many fields, the data centre segment among them. Even if AI is a promise that justifies investments across multiple layers of the technology production chain—of which data centres are only one—it is pertinent to dwell on the "stuff of dreams" shared by data centres and AI alike: data. In her work on digital technologies in agricultural production in Canada, Kelly Bronson (2023) shows how the notion of data carries an ideological-discursive charge that endows it with agency in its own right, while simultaneously presenting it as an immediate representation of the reality that produced it—"pre-analytical and thus beyond argument, as always existing just as it is" (85). She thus proposes the idea of the "immaculate conception of data" as an analytical framework to understand its abstracting tendencies, which "elevate data by stripping it of its mundane, messy, and potentially sinful origins" (97), while rendering

invisible the social and labor materiality of the productive processes underlying data production.

In data centre environments such as Peekaboo Telecom's, the data produced by sensors and by the matter that affects them (human and non-human alike) compose a temporal record of events in the monitored space, enable real-time inspection of ongoing performance, and provide the basis for future predictive models. This surplus of data makes the data centre a self-referential space, such that data production turns it not only into an archive of its own functioning but, above all, into a space for future interventions and enhancements. Thus, insofar as data are immaculately conceived[26] —even if implicitly, from the perspective of data centre players such as Carlos—data record a history of events that may become the substrate for the superposition of two temporalities: that of a present sustained by the metastable equilibrium of energy, heat, information, and labor; and that of a future that advances through the intensification of the flows of these four elements. The metastable present is comparable to a freezing of time, since the continuous character of the flows that keep a data centre operational relegates catastrophic failures to the realm of the possible. This freezing is, moreover, precisely the modus operandi of data centres and the service they provide, which companies translate into terms such as redundancy, reliability, and scalability. Indeed, it is scalability that enables temporal progression toward a future of quantitative expansion—that is, the proliferation of buildings, racks, servers, cooling machines, and the consumption of water and electricity.

The apparently excessive deployment of sensors in data centre ecosystems, therefore, is not a fetishism of security or a neurosis transformed into best management practices, but the very condition of existence of these spaces. Unlike analog media, in which variations in

26 Equinix, *2023 Corporate Sustainability Report* (Redwood City, CA: Equinix, 2024), PDF, https://sustainability.equinix.com/wp-content/uploads/2024/07/Equinix-Inc_2023-Sustainability-Report.pdf.

temperature and humidity represent a gradient of deterioration, “for digital media it tends to be binary: if it gets too warm for a second, the entire apparatus becomes nonfunctional” (Starosielski 2021, 208–9). Such binarity, as seen in the previous chapter, is the mode through which information infrastructures affect and are affected by the environment in terms of signal/noise, and this is no different for the functioning of digital equipment such as servers. However, while fiber-optic cables and points of presence must “clean” their surrounding environments so that the signal can flow safely, inside the data centre there is a dual movement of enclosure against the external environment and the engineering of the internal one. It is through this control that data centres “are also evidence of the continuing connection between digital systems and thermostatic operation” (212).

One cannot think about computation without thinking about cooling. Even domestic components such as CPUs, GPUs, and RAM have layers of thermal paste, plates with high thermal transfer potential, and fans. One of Starosielski’s central arguments is that media and technologies cannot be thought apart from their thermal dimension, such that their uses compose not only modes of subjectivity but also racial, colonial, sexual, and capitalist relations—in short, thermocultures. For Peekaboo Telecom’s sensors, heat is only one of the variables that compose the space. This does not mean that temperature is less important than humidity or access control, but for the manager of a data centre space it is a variable co-dependent with others. It could not be otherwise, since if every technology carries thresholds of functional and dysfunctional temperature, every architecture produces its environment. The microchip manufacturing mentioned at the beginning of this chapter is an example of this: temperature was only one of the variables to be controlled. As important as the amount of heat required for work to take place was the cleanliness of the production space, free of particles that could compromise components. Thus, the environment was organized less for workers’ well-being than for the security of microchips. Outrageous as it may seem, quality

control of commodities at the expense of workers' lives is nothing new, being merely an unfolding of labor alienation and commodity fetishism. What is peculiar in what was observed during fieldwork is the ambiguity—both technological and discursive—surrounding the production of the internal environment of a data centre.

Hostile to humans, comfortable for machines

My last fieldwork visit was to an engineering firm specializing in "turn-key" projects. It hosted a solutions architect[27] from a processor company. This company deals with high-performance computing and has participated in projects such as meteorological centres, which require large computational capacity for atmospheric calculations. During his presentation on a liquid-cooling system based on warm water for server cooling, the solutions architect mentioned, among other advantages, the reduction of noise in data centre installations, since water flow through pipes close to circuits is quieter than motors pumping cold air. This advantage was mentioned only superficially, which prompted me to ask about the relevance of making this environment quieter, given that human presence is generally brief and restricted. Both he and the others present—including a sales manager, the company's CEO, an operations manager, engineers, and an intern—had some difficulty answering. The sales manager mentioned that there are Amazon data centres with permanent security staff, who might benefit from this. The solutions architect, in turn, said that during client visits to tour the facilities—similar to those I had undertaken—there would be no need to shout to be heard, leaving a better impression of the installations.

This is not a consensus regarding the soundscape of data centres. During my visit to Peekaboo Telecom, Carlos insisted that I approach the servers, asking what I thought of the

27 Scala Data Centers, *2023 Sustainability Report* (São Paulo: Scala Data Centers, 2024), PDF, https://scaladatacenters.com/wp-content/uploads/ESG_Scala_Sustainability_Report_2023.pdf.

noise emitted by their fans. I replied that they seemed appropriate, to which he corrected me, saying that they were practically silent because the cooling system he had assembled spared the fans from working harder. To corroborate his argument, at a certain point in the visit we stopped in front of the two cooling machines. He fell silent, waiting for something, and seconds later they began pushing cold air with a noise that filled the entire room. Carlos looked at me, delighted and proud of this moment, in which any attempt at verbal expression would have to be made at full lung capacity. This moment was symptomatic in more than one sense. The engineering feat and cooling capacity symbolically performed in the motorized shriek of the cooling machines can be read as a continuation of a masculine ethos expressed on another occasion in the poor impression he had of interviewing a queer candidate.

Whereas in the job interview this ethos was expressed in terms of professionalism—pointing to the candidate's lack of preparation in contrast to an excess of symbols and attire signaling gender identity—the display of cooling can be understood in terms of what Gonzales Monserrate (2023) calls thermomasculinity. In his fieldwork across several data centres, one of the few female informants stated that "[t]he fear of downtime coupled with the masculine struggle to sustain uptime indefinitely through wasteful 'flood cooling' techniques, might explain why the data center industry took so long to implement sustainable initiatives" (338). In other words, anxiety about failing to maintain cooling prevented those responsible (mostly men) from implementing less wasteful and energy-intensive techniques.

Needless to say, Gonzales Monserrate's interlocutors did not justify their technical choices in terms of insecurities around masculinity, but rather through a sense of duty to keep the data centre operational at all times. Interestingly, as with Gonzales Monserrate, my field experience was composed mostly of male interlocutors. However, unlike his case, masculinity was not expressed through blunt overuse of cooling, but through dexterity and

planning in devising effective ways to climatize the environment. Carlos's case occupied a middle ground: while he used sensors and tracked indicators—contrasting with an earlier generation described by Gonzales Monserrate, for whom "[t]hey prefer to trust their 'guts' and 'senses' over dizzying screens with reams of provisional data from sensors and models" (336)—there was also a sense of wonder in seeing a large motor transforming energy into work, akin to a masculine taste for other engines that transform diesel into motion and greenhouse gases.

In this sense, the data centre ecosystem has an inhuman hostility, whose sensory aggression seems to refer to a hardened body, numb enough to tolerate unhealthy noise and a strictly functional architecture. During my visit to the Unicorn Data Centres data centre, I asked the guides whether they used ear protection, given that there were few moments when one could be heard speaking at a normal volume. They replied that the decibel levels at that moment had not exceeded a dangerous threshold. These auditory experiences were revealing of the contradiction between the simulacral imaginary described in Chapter 3 and what these spaces are in their normal operation. If idealized images evoke spaces of analytical contemplation over data and computers calculating discreetly, my experience was quite different. Undoubtedly, this experience aligns with the gender issues raised by Gonzales Monserrate (2023). In exploring the relationships between masculinity and temperature maintenance in data centres,specifically during critical moments in their operation, such as downtime, he argues that "is more than a state of service interruption or thermal runaway, it is a proving ground through which masculinity is conferred or denied" (8). In my case, they manifest in the aesthetic and technical assemblages that compose a data centre, whose factory-like character is closely related to a male proletarian subject, dwelling in dirty and noisy workplaces. However, as I intend to demonstrate below, I believe this is less a matter of affectation and concern about gender than the production of an inhuman space.

To do so, I return to the interview with the CEO of the "turn-key" project firm mentioned at the beginning of the chapter. When he describes data centres as places whose inhabitants perform sums, he is not resorting to poetic language. On the contrary, understanding this statement in its full literalness may require more imaginative effort than interpreting a metaphor. For if servers and other equipment "live" in the data centre, nothing is more evident than the need to treat them properly. This impression accumulated throughout fieldwork, as Unicorn Data Centres guides explained the various ramifications of measured variables for machine preservation and performance, and as Carlos showcased his company's achievements. Above all, a remark by the sales manager stands out while her boss was speaking with me. According to her, turn-key data centre projects are more complex and sensitive than those for hospitals. In my naively humanist surprise, I asked how that could be. She answered on two fronts: first, that the safety and care required by chains of servers are more complex and sensitive than those required for people in a hospital. The corollary is that the costs incurred if things go wrong in managing a data centre are greater than if a critical moment is mishandled in a hospital.

A realist capitalist stance might explain this as business as usual: after all, a hospital provides services just as a data centre does. One might even argue that as a key infrastructure underpinning countless other infrastructures, services, and institutions, data centres are indeed more important than hospitals. This paragraph, however, does not aim to come to terms with the devaluation of humans vis-à-vis the technologies they create, but rather to understand its consequences. Continuing the parallel between hospital and data centre, when the sales manager made this comparison, I was reminded of one of the machines that best encapsulates a mission-critical environment in a hospital: the Intensive Care Unit. These machines not only provide the patient's body with the resources necessary for survival but also transform that body into a locus of data proliferation. A data centre is at once a body in

imminent collapse (hence the need for permanent alert) and its ICU. This imminence, however, is continually pushed into the future, thus maintaining the permanence of the present in a metastable equilibrium. Its sensors refer to itself, and when they indicate disruption, its flesh-and-blood servants intervene to restore the lost balance.

My dialogue with the solutions architect extended beyond the meeting with the engineering firm through two video calls. The company he works for is a computer manufacturer with a significant share of the high-performance computing (HPC) market. As mentioned earlier, this is a computational mode crucial for tasks involving intensive calculations, such as meteorology, mining, and oil prospecting. I asked him about the differences between data centre spaces and HPC environments, such as supercomputers. In posing a comparative question, I thought HPC would differ from data centres in its concern for energy efficiency—assuming the former would be willing to sacrifice watts to deliver maximum performance, while the latter would prioritize efficiency. Or so I thought. He told me that since he began working in the field in the mid-2000s, HPC has already operated with the metric of FLOPS per watt—that is, how many arithmetic operations a processor can perform per watt. He mentioned two global rankings that benchmark supercomputers: the TOP500, which compares performance across supercomputers, and the GREEN500, which measures performance relative to energy efficiency.

As a solutions architect, part of his job consists in understanding the client's needs and resources so that his company can propose the most appropriate project. Thus, in his answers, he tended to mirror his clients' perspectives, comparing those who required HPC with those whose profile was closer to that of a data centre. According to him, although the scope of a data centre differs from that of a supercomputer, both are shaped by a paradigm shift that makes energy efficiency just as important as raw processing speed: the more watts are

converted into computation, the less heat is generated and the lower the overall energy consumption costs. Although environmental concerns were mentioned here and there during our two conversations, they were either justified or conflated, as if the *nomos* and the *logic* of economy and ecology were interchangeable.

We also discussed the technology he presented at the meeting—liquid cooling. I asked whether the use of water would not be harmful by consuming water resources, to which he replied that it is a closed system, in which the water heated by absorbing heat from components is then cooled as it passes through a cooling tower. His answer echoes a common counterargument to the criticisms raised against the installation of new data centres, such as in the case of a TikTok server in a semi-arid region of northeastern Brazil, where water scarcity is chronic[28]. His response and the technology he invoked reinforce the idea of the data centre as an environmentally neutral space, whose consumed resources are virtually unlimited due to its cyclical and lossless consumption. In this way, competition for better prices produces a race for efficiency that would result in new sociotechnical arrangements capable of mitigating greenhouse gas emissions. The Earth and the shareholders are grateful.

Conclusion

The aim of this chapter was not to lament or denounce the awareness of this or other interlocutors. For all intents and purposes, their ecological concern may be as sensitive as that of a Ph.D. candidate in anthropology. Rather, the goal is to make explicit how the data centre is an infrastructure that intertwines technological development—particularly in times of AI—economic development (along with, of course, the fear of bubbles such as the AI bubble bursting), and a hope of saving the environment. To that end, an environment composed of

28 Ascenty, *Relatório ESG 2023* (Campinas: Ascenty, 2024), PDF, https://ascenty.com/wp-content/uploads/2024/06/Relatorio-ESG-2023.pdf.

pipes, corridors, cables, and walls is produced, with the aim of taming the unpredictability of energetic and molecular interactions among water, air, electrons, and other elements that produce value. Water-cooling technology and its heating–cooling cycle reinforce an idea of time without end, requiring humans only for occasional repairs, or when the fiction of molecular control collapses.

A first conclusion in this regard is that these spaces oscillate between indifference and hostility toward people. This, however, is not exactly a problem. On the contrary, the general feeling during my visits was one of wonder at the organization of cables and ducts, the bits crunched, the energy distributed and consumed—as if this space were the manifestation of something greater than themselves, putting them in contact with a deep truth of their everyday lives. In a sense, this is indeed the case, but not in terms of a religious experience or an existential epiphany. Rather, it is an unveiling that produces a somewhat ambiguous feeling: it was visible among those who knew or presented the data centres a certain awe at the grandeur of these places, whether because of the endless rows of racks, the consumption of megawatts, or a low PUE. In this way, the data centre is also the latest iteration of a modern-capitalist dream of an ideal machine—whether in the form of unlimited circularity (a thermodynamic engine without energy dissipation) or in the generation of unlimited value, with the supposed circularity of processes and no loss of the resources it requires to function. Perhaps this is why the presence of human operators is so marginal in these spaces: they are finite in a space that proposes itself as infinite in its processes.

If the data centres that promote this circularity are structured under a homogeneous technical language, the geographical contexts in which they are situated are not. Thus, if heat is a “waste” to be avoided at all costs, one could say that countries of the Global South, due to their climate, are naturally more prone to producing this thermodynamic waste. In the same

way that racist pseudosciences once claimed that hot climates had deleterious effects on the morals and intelligence of their inhabitants—thus justifying the white man's burden to bring progress to such places—the Power Usage Effectiveness (PUE) metric, when measuring which data centres worldwide have the best coefficients, generally indicates that the top performers are located in the Global North, given its colder climate. This is not to suggest that technical aspects such as PUE were ideologically inspired by Rudyard Kipling, nor that there is a geographical conspiracy working against data centre actors in the Global South. If PUE is a fact (or an artifact, if we think with Latour and Woolgar) that gains relevance in the context of the climate crisis, then the response offered by industry players, as described in Chapter 4, is to intensify extractive processes over nature in order to transform it into "cleaner" energy. In other words, nature is exploited in order to save it.

Coda

Investing in the Future

Data centres are the future, or, at least, that is what I was able to distill from fieldwork, whether in the discourse of industry players, in the imagery mobilized in their advertisements and presentations, or in the way they frame the environment in their ESG reports. In a world marked by chronic and increasingly bleak diagnoses of an uncertain future for the environment and the beings that depend on it, data centres appear as a source of hope for the continuity of modern-capitalist abstractions, ideas, and worldviews. More than allies in the preservation of the environment, these infrastructures depend precisely on clean energy in order for the companies that manage them to prosper. This would thus constitute a virtuous circle in which the consumption of clean electricity begets value, which is reinvested in more data centres, consuming more clean energy, and so on.

As mentioned in Chapter 4, this trend came to the fore with one player's desire for the exponential growth of the data centre market in Brazil. This desire was not mere caprice, but a market imperative in light of the investments that data centre companies had recently made in Mexico and Argentina. Thus, competition for market share—both at the regional scale between countries and among different corporate capitals within the sector—drives the implementation of these supposedly salvific infrastructures. Moreover, the desire symbolized by an exponential growth curve is grounded in a substantial increase in the production of "clean" energy. One example of this is an unexpected difficulty faced by wind energy companies related to excess energy production. With nowhere for it to be consumed, surplus energy forces turbines to be shut down to avoid damaging transmission infrastructure.

This surplus of energy generation can be understood as a contemporary mode of primitive accumulation (Harvey 2004), characterized by the transformation of currents, irradiations, and radiations into a constant flow of electrons. As the CEO of a photovoltaic panel company demonstrated in his presentation, any non-human force capable of being transformed into direct current becomes an object of interest to be coupled to modern machinery and infrastructure. In this way of putting nature to work, there is a process of purification both in the discourse that such energy generation entails and in practice. The infamous imagery of dark smoke from burning fossil fuels, of coal miners consuming their lives in mines, and of upheaved tar sands is replaced by modes of violence that do not involve the emission of greenhouse gases, or whose damage has not yet entered common-sense imaginaries.

In the face of an increasingly real and irreversible climatic cataclysm, societies grounded in the instrumental use of both human and non-human entities for capital accumulation confront a dilemma: either they rethink their epistemology and conceptual instruments so that future generations may have a less painful survival, or they double down on the wager toward the abyss. Data centres and clean energy emerge as a bet in which nothing needs to be rethought, but rather faith must be maintained in the alliance between capital and technology—this time to save future generations from the sins committed by those that preceded them. In this sense, if abundant energy is the price to be paid for maintaining a way of life grounded in technological dependence as a means of capital accumulation, then flooding a complex biome or displacing an Indigenous people from their land becomes a small price to pay.

Beyond energy, another contentious point concerns a resource even more vital to life: water. One case mentioned twice throughout the thesis—the installation of a TikTok data centre in the semi-arid Northeast—is symptomatic of the kind of priority that this type of infrastructure invokes. Because it is located near the main cluster of submarine cables in South America

and an abundant supply of wind energy, the demand for water in a region notorious for its scarce rainfall becomes a lesser issue, at least from a business perspective. For local residents, however, the prospect of its arrival seems to reverse the temporality of waiting proposed by Burrell (2020). If for her waiting is a posture that "is experienced within a particular rhythm of material unfolding, often one that is slower than expected or desired" (286), for the inhabitants of Caucaia waiting is felt as an impending aggravation of a problem that is already difficult to solve.

This case adds to many others in which the arrival of data centres resembles a science-fiction cliché, in which an alien behemoth invades our poor planet to exploit its resources. My interlocutors, however, disagree with this interpretation. In addition to the solutions architect who pitched water-based cooling, other industry players I encountered came to the defense of TikTok's project. One of them presented technical arguments in response to an Instagram video by a left-wing influencer. The silver bullet of his defense was the claim that the water used for cooling is neither wasted nor discarded, reiterating an imagery of data centres as self-contained and environmentally neutral spaces.

Moreover, this is not merely a modern worldview or a capitalist ideology, but an individual investment that intertwines life histories with the success of a corporate investment. As the SENAI professor I spoke with put it, behind the construction of new data centres lies the hope of a change in a family's consumption pattern, the realization of personal dreams, and the myriad projects that give meaning to the exploitation of one's labor. In this sense, any dialogue that seeks to raise questions of environmental politics in this sector must take into account not only an understanding structured by technical language, as described in the previous paragraph, but also issues relatively external to the professional domain of these individuals. When I explained the nature of my research to this professor, I drew a parallel

between environmental and political issues, comparing Brazil's former president with the current prime minister of the Netherlands, both far-right politicians with populist agendas indifferent to the climate crisis. Upon hearing this explanation, my interlocutor slightly changed the way he looked at me, though I initially thought this was merely my own insecurity. Shortly thereafter, when commenting on what I had said, he referred to me as a "lefty" in a less-than-friendly tone. Politics, ecology, technology, and economy form a knot that is difficult to untangle.

Part of this intricate tangle gradually revealed itself as my interlocutors described the details of their work. By showing me the work of purification and manufacture of electricity in his data centre, Carlos performs, in his own way, a practice of translating local environmental relations into generic commodities (Pasek 2019). The entanglement of technique and nature in the construction and maintenance of these infrastructures, as in Thomas's case, resonates with Levenda's (2019) intuition that "digital capitalism [is] producing a new 'layer' of infrastructure that is at once technical, social, and environmental" (6). More than that, this layer distributes human and non-human agents under the aegis of exchange value. In this way, energy qua labor/time renders human and non-human nature equivalent under a metric precisely of what capital must extract in order to continue existing. Kinetic force situated within an ecosystem is transformed into computational operation and, above all, into the mechanisms that maintain the data centre's climate suitable for the comfort of the boards and servers it houses. As infrastructures whose primary inputs are energy and information, data centres operate by abstracting these two elements from the world, while everything else becomes waste—or, in Moore's terms, negative value.

Are my interlocutors right? Is concern over water scarcity merely a storm in a teacup? Their position is nuanced and manifests differently depending on context. As I showed in Chapters

2 and 3, the dominant discourse reiterated at public events is one of optimism that links the development of the data centre industry to the country's distinctive "green" energy potential. At the same time, the less public the context becomes, the more my interlocutors acknowledge that sustainability, and the means of redundancy and prevention against catastrophic failure, imply resorting to measures that run counter to sustainability policies. During my interactions with them, their expert position and the knowledge they shared made any counterpoints I raised sound like cheap technopessimism. Since my goal in these interactions was to allow them to articulate their perspectives, I rarely attempted to expand their understanding beyond the technical language underpinning their discourse, always unsuccessfully. While this impossible dialogue might be seen as a failure, it also revealed how techno-financial language composes an impenetrable symbolic architecture.

Beyond technical language, data centres require a certain kind of subjectivity. In discussing a data centre built in a bunker, Hu (2015) draws on Paul Virilio's reflections on bunker architecture and a Derridean understanding of melancholy to think through the condition of digital data in contemporary times. His argument articulates a psychoanalytic understanding of melancholy—as a mechanism tied to a loss so painful that it produces an identification between the mourning subject and the lost object—with bunker architecture, which, following Virilio, Hu describes as another name for a crypt that prefigures reincarnation. In this way, stored data become the digital equivalent of a suspended undead. He argues that the maintenance of the data centre as a data crypt is formed by two affects: first, paranoia regarding the site's security against the imminent risk of disruption; second, melancholy manifested as attachment to the data it stores.

The way he synthesizes his argument is telling: "the fever around data bunkers, manifested in the desire to secure or defend data, is in fact a melancholic attachment to the data" (108).

Curiously, fever is precisely what must be eliminated from these environments, both literally —as heat—and in terms of the ethos required to operate them. Here I return to my field experience, in which both a member of the military and a former airline crew trainer were absorbed by data centre companies. Both explained that their professional training made them desirable hires for data centres because these are mission-critical environments. In the case of my uniformed interlocutor, one might think of his category as producing docile bodies in Foucault's (1979) terms, where what matters most for bodily performance is "the place it occupies, the interval it covers, the regularity, the good order according to which it operates its movements" (164)—that is, the capacity to execute hard skills, as mentioned in Chapter 3.

A similar logic applies to the former flight crew trainer. Internalizing procedures, making them communicable, and executing them efficiently is essential both to keeping airplanes in the air and to keeping data centres running. The risk of a plane crash and the risk of a data centre failure are never zero, but variables whose value is always uncertain, always lurking. Failures in data centres represent financial loss and reputational damage, as companies seek to capitalize on their competitors' incidents. Thus, an ethos centered on preparedness and vigilance seems to gravitate not toward melancholy, but toward paranoid concern over incidents. In this sense, data centres are the ideal habitat for this type of subject, as they house devices that are simultaneously complex and fragile, subjected to climatic and technical variables that, if misaligned, can culminate in catastrophe. Added to this are external variables in regions sensitive to the climate crisis, prone to droughts and destructive storms.

According to Hu (2015), the paranoid subject "can't tell friend from enemy, and is threatened by that which allows friend and enemy to mix. If friend can appear as enemy and vice versa, then the paranoid subject may lash out against certain manifestations of this phenomenon. But the ultimate target of her anger is the system behind these phenomena" (19). In the case

of a data centre, paranoid projections are not articulated in terms of friend or enemy, but rather in terms of the elements that constitute its operation, such as value and waste, efficiency and wastefulness, order and catastrophe. The "human factor," sometimes mentioned by my interlocutors as a challenge to be solved, is also a site of risk emergence, occupying not a position of agency over non-human risks, but one of equivalence.

What, then, is the object that constitutes the paranoid subject so desired by data centre managers? Beyond arc flashes and power surges caused by lightning strikes, it is above all necessary to think conceptually about the object that composes this ethos and inhabits data centres. Of course, there are risks related to cybersecurity, which are human, intentional, and goal-oriented. These were rarely mentioned during fieldwork, but they are no less real. However, the most feared and frequently mentioned risks were those that simply exist and emerge out of nowhere, such as the electrical phenomena mentioned by Carlos, the fire that struck Unicorn Data Centres, or the scorching summer that required the use of generators to reinforce cooling. These phenomena have human origins—after all, it takes a data centre for there to be a data centre incident—but their emergence has no intention or purpose; they simply happen. They exist by virtue of the potentiality of matter itself, its degradation, unexpected associations, and the small but real probability of unforeseen behavior. In short, data centres exist within a contradiction: they must function through an ideally cohesive and constant material orchestration, yet the very materiality that constitutes them can betray them. The continuity of uninterrupted operation is therefore a struggle against the very materiality from which they are made.

Climate as a Service

The fight against catastrophic failures in a data centre aims at maintaining a climate that allows computational work to proceed without interruption. As is well known by this point in the thesis, this work ranges from internet access and the many services enabled by it to specific corporate uses, such as the training of artificial intelligence models. The latter case is emblematic of the importance of data centres, as it requires an orchestrated effort of multiple GPUs performing uninterrupted computational calculations. In this sense, a disruption can render all invested resources worthless. This example simply makes clear that data centre downtime represents not only a concrete loss of invested resources, but also financial loss for both the data centre's clients and the data centre itself, which has a contractually established maximum annual downtime. It could not be otherwise, as this reflects what Unicorn Data Centres guides told me about the contractual establishment of climatic variables for clients' equipment.

One of the main aspects of producing and controlling a data centre climate is the separation between hot and cold airflows. Details in the design of the Unicorn Data Centres and Peekaboo Telecom data centres showed how the possibility of mixing hot and cold air represents, at best, a performance and energy-efficiency problem, and, at worst, a catastrophic failure. Separating cold and heat is equivalent to separating value and waste. More than that, this separation refers to a thermodynamic understanding of how a system operates. This understanding dates back to the mid-nineteenth century with Sadi Carnot's theoretical formulation of the steam engine, conceptualized as a cycle of energy transformation into work.

Let us then return to Stengers's reflections on the development of thermodynamics. When discussing the steam engine, she states that "Carnot's aim is to raise the stakes to the highest

point and conceive of an ideal representation such that any output greater than that predicted by this representation would lead to the absurd possibility of the 'free' production of work" (205). This absurdity would only be possible at a theoretical level, in which the cycle of transformation from heat to work could be reversible—that is, if the arrow of time could rotate 180 degrees. Coincidentally, the dream of "free" work is also that of any capitalist, in which the surplus value extracted from workers could be maximized. It is in this parallel that Stengers points out that "[t]he ideal of functioning defined by Carnot for the heat engine seems to have for an analog in the social what we will call a circulatory utopia" (210), such that "the logical extension of the same utopia appears like the putting to work, this time generalized, of an ideal à la Carnot: the complete integration of all activity within the system" (211).

The period analyzed by Stengers is one of the hegemony and proliferation of disciplinary institutions such as the modern army, as described by Foucault and cited earlier. What matters here is how Stengers offers a way to understand sociotechnical processes in the production of the modern subject and capitalism. If capital is the matrix of social relations of production and discipline is the architectural and procedural grid imposed on bodies to produce a productive subject, then the steam engine was the technological paradigm of the time, such that its logic was abstracted into thermodynamic and social utopias. One may think, for instance, of Charles Fourier's phalanstery, whose architecture sought to encompass the totality of its inhabitants' lives, both in their subjectivity and their productivity. The times of production and social reproduction were equally subject to the administration of this space, so that no aspect of the subjects' labor was "wasted."

Even with social and technological changes since the age of the steam engine, some abstractions persist in new material and social configurations. By proposing that the water

used to cool servers circulates without loss, the solutions architect I interviewed implies that the data centre can be a closed and self-sufficient system. Even if more subtle, the comparison between data centres and the steam engine is not entirely implausible. Energy dissipation is inevitable, but that does not mean it cannot be mitigated or redirected to heat homes, highlighting an "industrial-infrastructural intimacy and dependency" (Vonderau 2019, 7). If heat is waste, and, following Mary Douglas (Michael Thompson's advisor), if waste is something out of place, then heat, if it cannot be suppressed, must be relocated. In this sense, the struggle against entropy consists in maintaining the separation of differences, such as cold–value and heat–waste.

In terms of energy, the dream of "free" work seems to become reality in "green" energy. Hydroelectric plants embody the idea of circularity in terms different from Carnot's cycle, yet still presupposing indefinite repetition. The reality that frustrates this dream, however, is that neither the Sun nor a river produces energy on its own; both depend on photovoltaic panels and dams, which themselves exist through human labor and violence, as explored in chapter 4. Labor, in turn, presupposes organization and is the means of maintaining it. In this sense, Wiener's notion of entropy, even though he developed it with a focus on information, can be used to understand the technical and architectural elements of a data centre as means of maintaining order within its space, as is the case with hot and cold aisles. If the various sociotechnical arrangements around temperature shape the flows of heat and cold, then data centres can be understood as dealing with heat differentials in both the thermodynamic sense —like a steam engine—and in Wiener's sense, since these differentials are not only energetic and thermal but also informational. In other words, such flows are sensed and translated into information through the use of sensors, cameras, switches, and a myriad of devices that make up the technological ecology of data centres.

Thus, alongside energy, information is a constitutive element of computation. As the literature review showed, the modern concept of information was developed by Claude Shannon and the aforementioned Norbert Wiener. While the former conceptualized information by equating it with entropy—that is, the potential for change it can provoke—the latter understood entropy analogously to its thermodynamic meaning, associating information with order and, in contrast, noise with chaos. Both definitions are pertinent for understanding data centres as spaces in which the production of value is intimately linked to entropy. Wiener's understanding of information as negative entropy allows us to grasp the materiality of a data centre as a site whose efforts are directed toward maintaining an order that preserves the differentiation of energy flows. This is the condition under which Shannon's entropy—that is, information—can occur. In a data centre, Shannon's notion is both opposed to and complementary with Wiener's, since the order maintained in this space enables the potential for surprise, for state change, that information inside and outside servers may have. This information, as Andrei intuited at the end of chapter 5, has infinite value precisely because it possesses a potential for surprise and randomness—that is, the possibility of the emergence of the new.

When Andrei speaks of infinite value, he is not referring to the information produced by data centre sensors, but to the information circulating in the servers of the companies they host. In this sense, data centres are the condition that allows companies to transform information into products or services by maintaining negative entropy (Wiener 1989). In other words, the value produced by data centres lies in providing a service in which climatic variables are kept in order so that the information computed on servers can become a commodity. Like any capitalist enterprise, it is assumed that the service offered by data centres entails the exploitation of labor. But what—or who—is being exploited?

Chapter 4 offers a partial answer. Data centres, as described in chapters 2 and 4, consume large amounts of electricity. This energy, in turn, comes from the exploitation of non-human nature, whether from rivers reshaped into dams or from the Sun and wind, whose capture is no less disruptive for those living near photovoltaic panels and wind turbines. However, "consumption" is a term that conceals some of the work done inside data centres, such as cleaning the energy that comes from the grid, adjusting its voltage, and efficiently channeling it to different devices such as Uninterruptible Power Supplies (UPS), Power Distribution Units (PDU), and other safety and redundancy devices that ensure energy supply to servers. Finally, electricity is reworked so that it can be safely used in the operation of massive quantities of servers. This work inside data centres obviously involves the exploitation of the labor of technicians responsible for handling electricity.

Thus, between the capture of non-human forces and energies, their transformation into electricity, and their conversion into safe loads for the operation of servers and auxiliary equipment—notably cooling and air-conditioning systems—there is a process of economization. This is because "[t]he forces that explain the circulation-transformation of things are the same forces that give things value" (Callon and Çalışkan 2009, 389). This was evident not only in how energy is handled in the two data centres visited, but also in conversations with different actors about the free energy market and how energy is purchased "in bulk," as Carlos described. In other words, as non-human nature becomes part of capitalist culture, it acquires exchange value as an attribute, often cheaply (Moore 2015).

So is the core of value production simply that data centres are buildings that "digest" electricity to be consumed by their clients? No. As described in chapter 6, data centres are sites of molecular-level surveillance, such that the information produced by air currents and the presence of technicians enables granular and often automated control. If these devices

function largely on their own, then there are few workers to be exploited. Is surplus value obtained from this exploitation? Are sensors and cameras the source of value? Here one can consider Caffentzis's (2013) reflections on the supposed value generated by automata completely independent of human beings. More specifically, his interest lies in answering a (still) hypothetical question about value production by self-reproducing automata. According to him, capital accumulation in an economy where production is entirely carried out by autonomous robots would be impossible, since surplus value extraction comes from living labor—that is, from human workers. His conclusion is that if capital accumulation is increasingly difficult in digitized economies, then surplus value is not predominantly obtained in the digital sector, but in the extractive activities that manufacture the electronic components of that sector.

Are data centres, then, a bad excuse for the perpetuation of well-known forms of primitive accumulation, notably the mining of rare metals? Undoubtedly—but no more so than the army of devices that permeate our lives. For data not only possess materiality; they can also have exchange value, that is, become commodities insofar as they result from capitalist sociotechnical assemblages (Bronson 2022). This does not entirely refute Caffentzis's proposition, since information is indeed the product of labor. The task, therefore, is to delineate the kind of labor that distinguishes data centres from other infrastructures—more specifically, to understand exactly what is being sold through data centres.

This is the fundamental distinction of data centres compared to the infrastructures they depend on: while hydroelectric plants and wind turbines depend on climate in order to function, data centres are themselves the climate. While regulating the air and energy variables within their space, they produce a climate that is purportedly independent of the outside, intensifying their appeal in the context of climate crisis. While droughts can ruin

crops and rains can destroy cities, data centres guarantee that the equipment under their care will function 24/7. Added to this is the fact that data centres are sold as the perfect solution to environmental and economic crises. Subject to energy transition policies, their proponents argue that the more profitable they are, the less damage they cause to the planet. This guarantee rests on the automation of monitoring devices, but also on the automation of the worker, reducing them to a versatile tool endowed with specialized knowledge of this type of infrastructure and efficient at resolving catastrophic failures in a timely manner.

Thus, what data centre companies truly offer is something that could be called Climate as a Service (CaaS). Drawing on the corporate vernacular I encountered during the research, this term alludes to platform economies that concentrate a given resource, whether software (SaaS), banking (BaaS), or infrastructure (IaaS). Although data centres fall into the latter category, their proponents—especially industry players—understand them as means of compensating for a dual loss: first, the loss of climate itself, which is increasingly unpredictable and extreme; second, the loss of climate as a commons, which, impossible to capture as private property, has been exploited to exhaustion. This exhaustion—visible, for instance, in phenomena such as polar ice melt, intensified tornadoes, and prolonged droughts—is experienced as a growing state of chaos and indifferentiation, that is, high thermodynamic entropy, making the continuity of the modern way of life—and therefore the future—ever more uncertain. At the same time, and paradoxically, the technological enablement of climate through the calibration of thermal, energetic, and atmospheric variables offered by data centres becomes a solution, even if only a technological fix (Jobson 2020), in which a form of order—and thus a future—remains possible.

The fact that this service is dedicated to computing machines, rather than to other purposes such as providing affordable thermal comfort to inhabitants of extreme climate zones, is no

coincidence. In a conversation with Carlos, as I tried to understand what distinguishes data centres from other places that require a specific climate, I attempted to compare them to a meat plant. He found the comparison absurd and foolish, since, according to him, meat plants simply push cold air to slow meat decomposition, whereas data centres must precisely calculate variables such as humidity, temperature, air pressure, and wind speed. In short, computers require climatic care to function, and they require granular and intensive care to be profitable.

Beyond the most evident and outrageous conclusion of these imperatives—already explored in chapter 6 in relation to integrated circuit production—that the means of production of a commodity matter more than aspects external to capital accumulation (commodity fetishism), it is worth noting the place the digital occupies in contemporary society. The encoding of the world into data has become a condition of existence for modern subjects, and this author is no exception. In other words, our relationship with the world increasingly depends on computation at levels we barely grasp. The various aspects of contemporary human life that are intimately tied to this process are evident and need not be enumerated. This is no different with climate. On the contrary, the more the planet becomes a hostile and uncertain place for the reproduction of the modern-capitalist way of life, the more investment is placed in producing private environments that emulate climates through the digital encoding of their features. Or, in Starosielski's (2021) words: "As transmission accelerates and data accumulates, generating more and more heat, the need for a cooling apparatus to stabilize it only grows. This is media's thermal loop" (212). Not only is she right, but her insight can be expanded beyond the thermal dimension. Media's loop encompasses multiple dimensions of matter and, as the final argument of this thesis suggests, of time as well.

Consuming Futures

The modern subject understands nature—that is, the relations between living beings (generally excluding themselves) and matter—as a set of cycles. In school, one learns about the water, carbon, and nitrogen cycles, each of which feeds rivers, enables plant photosynthesis, and fertilizes the soil. As Latour and Woolgar argue, these cycles are not merely facts but artifacts, insofar as they are framed within modern epistemologies through abstractions and measuring instruments. Animals such as human beings, including modern ones, depend on these cycles and have their own, such as those that make up their physiological dimension. Understanding these cycles has made it possible to exploit both raw materials and human and non-human labor. Plants need time to grow, dams must wait for river flows to fill, and workers need rest in order to continue being exploited.

Authors such as Foster (2000) have already pointed to the disjunction between natural cycles and cycles of capital accumulation in terms of a metabolic rift. Data centres, even if they do in fact mitigate the consumption of fossil fuels, are still actors within the various modes of exploitation that constitute the metabolic rift. Indeed, it is precisely this contradiction that drives the proliferation of this infrastructure: as a capitalist enterprise, it is part of the environmental degradation and the climate crisis that emerge from it; at the same time, data centres tie profitability to efficient energy use—that is, to the "sustainable" use of green energy. This contradiction is not new. Bond (2022), mentioned in chapter 4, shows that oil companies in Alberta exploit tar sands under the justification that, after extraction, they will carry out terraforming that will leave the exploited region better than it was before the project. Although such justifications are PR moves that satisfy only the most naïve, they are grounded in a reality that is difficult to deny: modern-capitalist societies depend on the exploitation of resources in order to survive and progress.

While the climate crisis calls human survival into question and raises doubts about progress, data centres offer an escape from this environmental–epistemological crisis by selling the idea of a controllable climate. Beyond the privatization of climate as one of the few remaining commons in late capitalism, what is at stake here are the possible futures that data centres and the climate crisis place in play. If "[l]ife is an island here and now in a dying world" (Wiener 1950, 95), then one can say that an environment with regular cycles of different materials and nutrients is capable of sustaining living beings as they reproduce their genetic material and societies as they reproduce their culture. This is not merely the reproduction of the same, but the emergence of the new—from butterflies with new patterns on their wings to different languages and cosmologies that, rather than simply "representing" the world, conceive of other universes and ways of thinking it.

As the environment that shelters these beings and societies is degraded, they are placed at existential risk. If different climates and biomes constitute distinct states of a metastable equilibrium on the planet, then, in Wiener's terms, the systemic effects of pollution arising from industrial capitalism lead to an increase in entropy. Consequently, in a system incapable of dealing with excess waste, residues accumulate as garbage or noise. The cumulative character of this process translates not only into increasingly intense climatic phenomena, but above all into increasingly unpredictable ones. This unpredictability, in turn, can be understood as a state of chaos or sameness, which, under Wiener's framework, can be considered a state of high entropy—incapable of sustaining life—since a climate unable to host life is like white noise, disaggregating any possibility of information, thought, or culture.

Data centres, in turn, are the antithesis of this hostile panorama. Climate is not only controlled, but the information produced by their energetic and atmospheric elements helps keep it under control. One might say that such an antithesis, in the face of the entropy that

threatens life in the external environment, is desirable. The modular, closed, and digital character of a data centre is certainly of a different nature from the environment external to it. In its own way, it is a means of sustaining life and culture—not only for those who work in and profit from these spaces, but also for those who depend on them in order to consume what derives from their computational processes. This, however, should not be seen as hope or as a triumph of modern instrumental rationality's technological prowess. The data centre's gambit lies in dealing with risk through uniform proliferation. Behind different tiers of redundancy and the various techniques and architectures that give them form, they are subject to standards of quality and safety (Easterling 2014) that maintain homogeneous and predictable operation.

In other words, data centres are infrastructures that directly and indirectly consume the external environment. This external environment exists in its variability and in the possibility of emergent events, thereby producing different forms of life and material dynamics. Data centres, by contrast, are standardized and sensitive to emergencies, which in their technical vernacular are called "catastrophic failures." The environment of a data centre is the opposite of the environment external to it, as is the temporality of each. Examining the temporality that takes shape in financial-derivative logic during an ecological crisis, Orit Halpern (2017) states that "[t]ime here becomes not a relationship to the spatial circulation of goods, labor, and commodity, but a thing-in-itself, a non-historical, but also non-geological or environmental time. Time has become a pure ecology of self-reference" (7). Despite the cooling of data centres, time is not frozen, but twisted into a spiral by reference to its previous state, so that its future becomes the repetition of the immediately preceding second, infinitely, as some of my interlocutors imagined.

This is both its allure and its curse. Data centres are the future.

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