UTOPIA COMPUTER

The »New« in Architecture?

Nathalie Bredella, Chris Dähne,
Frederike Lausch (Eds.)

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The critical concern of the book “Utopia Computer” is the euphoria, expectation and hope inspired by the introduction of computers within architecture in the early digital age. With the advent of the personal computer and the launch of the Internet in the 1990s, utopian ideals found in architectural discourse from the 1960s were revisited and adjusted to the specific characteristics of digital media. Taking the 1990s discourse on computation as a starting point, the contributions of this book grapple with the utopian promises associated with topics such as participation, self-organization, and non-standard architecture. By placing these topics in a historical framework, the book offers perspectives for the future role computation might play within architecture and society.

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DONAL LALLY

All that Is Solid Melts into the Cloud

The data centre is the infrastructural backbone of Cloud computing. By 2027 data centres will come to consume 31% of Ireland's total electricity demand. However, the Cloud metaphor draws the public's attention away from the fossil-fuel derived energy used to operate and maintain their environmental controls and from the vast quantities of resources that make this kind of architecture. This article attempts to dispel the techno-utopian fantasy that is the Cloud by typologically connecting the data centre to historic fire-burning infrastructural typologies.

"In Bedlam hell is brilliant, a fire in the head.
The men I worked among worked in hell–
moon men I called them, phases of the moon.
hey'd stand all day in fire and stoke and dip and pour
and go home white as potter's clay.
I have seen the furnaces in the picture, the furnaces at Bedlam.
The night sky is torrential, a red and yellow storm,
the silhouette of buildings like a house on fire,
Yet the horses with the wagon in the foreground,
Make the scene almost pastoral…"
Stanley Plumly[1]

It is a hot July day in Dublin. A technician removes a glove and presses her palm against a biometric scanner. Her masked companion pushes open the unlocked door—breath turns cloudy. The

1 Stanley Plumly, "'Coalbrookdale at Night' by Phillipe Jacques de Loutherbourg," The Georgia Review 37, no. 1 (1983): 190.

server hall is deep and wide. The low ceiling is a complex matrix of ducting and lighting. The floor a chessboard grid of floor tiles. The ice-cold air and the all-encompassing machinic din palpable through the technician's protective suits. Their destination is an empty caged room at the far end of the hall. Outside the cage lies a stack of cardboard boxes containing server cabinets, servers, and cables. They are employees of a computer game development company and the first clients to call this space home. Via CCTV, a security guard watches the two figures work, slowly freezing in sub-zero temperatures.

A data centre is a building designed to safely house and operate computer systems and associated equipment. Once a company's data centre could be stored in a cabinet, as computational needs expanded over time, they grew to fill entire floors. Now, a data centre is commonly the size of a warehouse, can demand as much electricity as a small city, and consume as much water as a large town.[2] The term "data centre" can be understood as a catch-all for many different operational modes; each mode has a different level of overlap with the public and private sphere. Broadly speaking, the fundamental architectural figure of a purpose-built data centre, that of a large non-descript shed, remains consistent across each mode. A data centre should be understood as more than a discrete and immutable architectural object. Virtualised infrastructures have enabled global connectivity via a vast constellation of discrete data centres, each linked through a planetary-scale network of on-land and subsea cabling, creating the connected computational network commonly referred to as the *Cloud*. When utilising virtual infrastructure, a data centre can extend across multiple public and private Clouds to the edge of a network (or networks) through mobile devices and embedded computing. Depending on the operator, two different data centres' architectural and infrastructural requirements may be quite different to one another. For example, the NSA or the Pentagon

2 Killian Woods, "Data centres use same amount of water as large towns," Business Post, June 14, 2020.

will have more stringent security requirements than a colocation data centre; a company such as Netflix may require more complex content delivery infrastructures. A colocation (colo) data centre hosts client's servers and networking equipment by renting out the physical space, power, bandwidth, IP addresses and cooling systems to their clients and provide security systems to protect against outages. The server hall in a new colo essentially starts out as an empty refrigerated room. As new customers rent space to install their servers, the hall slowly warms up with the heat of the additional computational exhaust. The server hall's cooling systems are tasked with maintaining an ambient temperature somewhere between 15–22°C. A cooling mechanism failure would lead to a system crash, or, as in the Bangkok Bitcoin mine, can lead to an inferno.[3] Data centres are responsible for up to 1.5 per cent of global electricity use,[4] forty per cent of which is used for cooling server halls.[5]

The Cloud

In recent years ethical questions around how our behavioural data is harvested and commodified have occupied a central role in public debate. However, there is a growing public interest in *the what*, *the where*, and *the how* of data storage and circulation. The Cloud is the metaphor used to describe the computer servers, their attending software, and data archives, that are accessed through the Internet. The Cloud is where your Facebook, Instagram, and Twitter posts live. The Cloud is a heterogeneous assemblage drawn together from rare earth minerals: coal, oil, and gas, and renewable energy infrastructures: subsea cable networks, data centres, on-land fibre optic cables,

3 Rich Miller, "Fire at Bitcoin Mine Destroys Equipment," November 6, 2014. Accessed August 19, 2020. https://www.datacenterknowledge.com/archives/2014/11/06/fire-bitcoin-mine-destroys-equipment.

4 Eric Masanet et al., "Recalibrating Global Data Center Energy-Use Estimates," Science 367, no. 6481 (2020): 985.

5 X. Zhang et al., "Cooling Energy Consumption Investigation of Data Center IT Room with Vertical Placed Server," Energy Procedia 105 (2017): 2048.

ethernet cables, and domestic routers, all knitted together by complex supply chains and hidden labour practices. The Cloud, a metaphor that points to something remote, ethereal, and not of us, successfully renders the vast material networks that support the internet invisible to our collective imagination. It is a metaphor that is convenient for those providing industrial Cloud computing services, but, it is also convenient for us, as it alienates users from the environmental consequences of being online. The Cloud is the new industrial sublime; a paradigm-shifting technological achievement that should be understood as the latest instalment in the violent story of industrial progress. The Cloud is dirty; it is made of smoke. This article examines how the utopian fantasy of the Cloud is perpetuated; by using both theory and fiction it attempts to make visible some of the material and spatial conditions caused by the Cloud.

The techno-mysticism of the Cloud

The prevalent PR representations of a data centre are carefully mediated imaginaries. The well-publicised and iconic interior space foregrounded in public relations imagery is called white space (figs. 1–2). The white space is where the server cabinets live and where the computational heat needs management. Therefore, it is the most energy-intensive space in a data centre. For sociologist Alexander Taylor, the white space is one of purity and potential that "plays an important role in mediating and transforming popular imaginaries of the Cloud."[6] The white space is portrayed as a ripe and usable space designed to attract investors. For journalist Andrew Blum, a "data centre is designed for machines, but the customer is a person, and a particular kind of person at that… a data centre is designed to look the way a

6 A.R.E. Taylor, "The Technoaesthetics of Data Centre White Space," Imaginations Location and Dislocation, Global Geographies of Digital Data, no. 8-2 (2017). Accessed August 19, 2021. http://imaginations.glendon.yorku.ca/?p=9947.

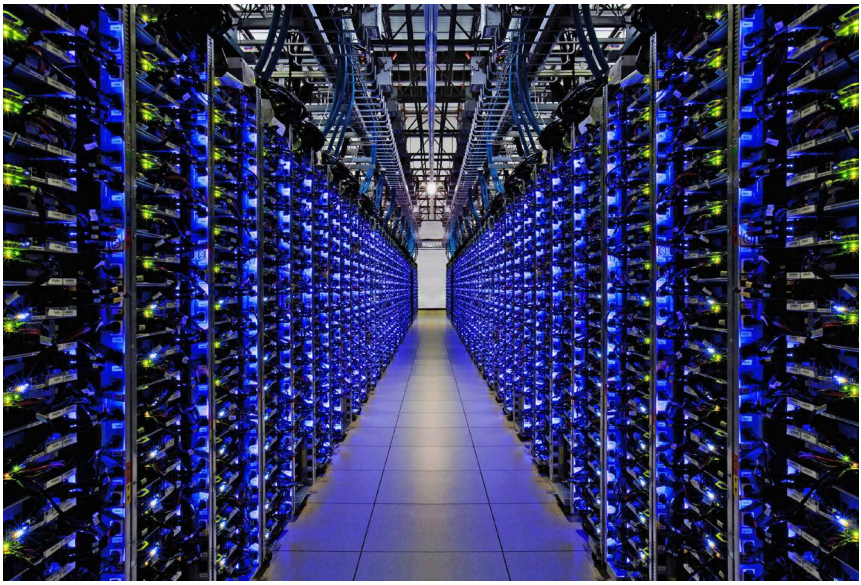

Fig. 1: White Space, Google Data Center Server Room, Douglas county, Georgia, USA. Source: https://www.google.com/intl/de/about/datacenters/gallery/#douglas-county-servers, protected by copyright

data centre should look, only more so: like something out of The Matrix."[7] Jay Adelson, the founder of the Equinix Global Internet Business Exchange, describes the performative aspect of the interior, "If you brought a sophisticated customer into the data centre and they saw how clean and pretty the place looked—and slick and cyberrific and awesome—it closed deals."[8] These cyberrific white space interiors are represented as providing a hermetically sealed, retro-futuristic environment, free from disease (cyber warfare, viral attacks) and free from human occupation. Statistically, humans represent the likeliest cause of data centre downtime. For Taylor, this design aesthetic is grounded in an imaginary of techno-nostalgia, one that referenced the popular science fiction cinema of the 20th century, for example, "THX1104"; "The Matrix"; and "2001: A Space Odyssey."[9]

7 Andrew Blum, Tubes: Behind the Scenes of the Internet (London: Viking, 2012), chap. 3, Kindle.

8 Ibid.

9 A.R.E Taylor, "The Technoaesthetics of Data Centre White Space."

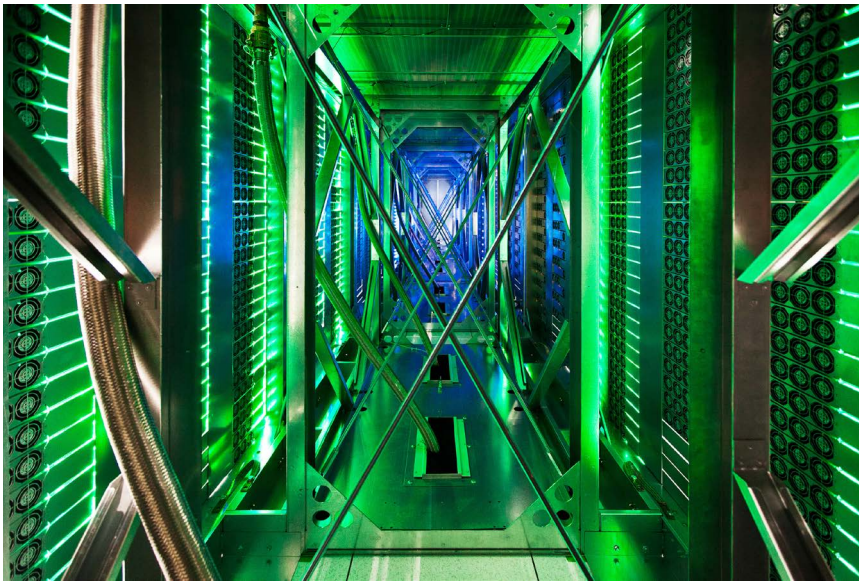

Fig. 2: White Space, Google Data Center Server Room, Mayes County, Oklahoma, USA. Source: https://www.google.com/intl/de/about/datacenters/gallery/#mayes-county-server-aisle, protected by copyright

The supporting infrastructure is located in the data centre's *grey space* (fig. 3) and is responsible for maintaining uptime—the systems' online availability. Downtime is the amount of time a system is unavailable—an estimated one hour of downtime on Amazon's servers during their 2018 Prime Day sale caused a loss somewhere between seventy-two and ninety-nine million dollars.[10] In the event of a power cut, backup diesel generators and batteries are used to maintain constant uptime. Environmental controls are provided by air conditioning units, heating systems, ventilation systems, and exhaust systems. Security typically consists of biometric scanners, guards, and video surveillance. Operations staff monitor and maintain the equipment from a centralised location using software such as data centre infrastructure management (DCIM). Grey space, the more mundane, rarely features in PR imagery.

10 Sean Wolfe, "Amazon's One Hour of Downtime on Prime Day may have cost it up to $100 Million in Lost Sales," Businessinsider, July 18, 2018. Accessed August 31, 2020. https://www.businessinsider.com/amazon-prime-day-website-issues-cost-it-millions-in-lost-sales-2018-7.

Fig. 3: Grey Space, Google Data Center, Cooling Plant, Hamina, Finland. Source:https://www.google.com/intl/de/about/datacenters/gallery/#hamina-cooling-plant, protected by copyright

For the architect and theorist Rem Koolhaas, data centres are part of the new rural architectural sublime.[11] At the Supernap data centre facility in Nevada, Koolhaas finds an architecture for "which no one is prepared… abstract and codified—uninflected by human need, distant from us and nevertheless produced by us and needed by us."[12] In his writing, Koolhaas uses descriptions such as "distant" and "beyond our imagination." In doing so, he reinforces the utopian fantasy that the processes that underpin Cloud computing are somehow ethereal and difficult to fathom. The PR imagery would have us believe a data centre operates as a perfect, quiet, remote, self-regulating autonomous machine. This is misdirection. Instead, we must understand them as a complex entanglement of matter and energy; data centres have "nothing to do with Clouds" but "everything to do with being

11 Rem Koolhaas, in Countryside: A Report (Köln: Taschen, 2020).

12 Rem Koolhaas, "The Cut: Where to from Here, When All the Horizon is in the Cloud," Flaunt.com, 2016. Accessed August 31, 2020. http://www.flaunt.com/content/art/rem-koolhaas.

cold."[13] Koolhaas asks, but fails to answer, the right questions: "How or what do you call life in this building? Do you call it life or process? What, as a profession, are we doing with these types of environments? Does it lead to techno-mysticism?"[14]

Formax

Contemporary technologies conceal the source of their power. The technological sophistication of the equipment that enables Cloud computing makes opaque the material and energetic forces at play in its operation. Dublin, Ireland, is currently home to the largest assemblage of data centre capacity in Europe. It is forecast that by 2027 the Irish data centre industry alone will consume thirty-one per cent of all available electricity on the national grid.[15] For the philosopher of technology, Gilbert Simondon, technical objects have a technical essence that places them in a genealogy alongside other technical objects.[16]
Identifying this genealogy allows one to connect contemporary technologies to their primitive ancestors. The data centre is an urban scale container technology that maintains, renders safe, a constant supply of electricity to its servers, and mediates the exhaustion of large quantities of waste heat produced by the servers. Electricity is a kind of "repressed fire,"[17] meaning the hearth, the furnace, and the data centre are kinds of container technologies, each tasked with rendering safe, and making useful, extreme temperatures. Philosopher of elemental media, John Durham Peters, describes container technologies as "the ground that brings out the figure but disappears in doing so."[18] The

13 Blum, Tubes, chap. 7, Kindle.

14 Koolhaas, "The Cut."

15 Donal Lally, "The Sacred Fire of a Data Centre," Strelka Magazine, October 2, 2019. Accessed August 31, 2021. https://strelkamag.com/en/article/the-sacred-fire-of-a-data-center.

16 See chapter two of Gilbert Simondon, Cécile Malaspina and John Rogove, On the mode of existence of technical objects (Minneapolis/MN: University of Minnesota Press, 2017).

17 John Durham Peters, The Marvellous Clouds: Toward a Philosophy of Elemental Media (Chicago/IL: University of Chicago Press, 2015), chap. 3, Kindle.

18 Ibid.

hearth and furnace bring forth the figure of fire, the data centre brings forth the figure of the Cloud. One may imagine a container technology to be impermeable or sealed—but to seal something is to assume the seal will eventually be broken (eggs, tombs, time capsules, etc.). A container requires the existence of a hole, it presupposes a vacancy: "containers are supposed not to leak, but to pour."[19] From the hearth, we generate heat and light for our homes; from the furnace comes the steel and bricks used to build our cities; from the data centre comes our digital existence.

The Cloud is maintained with electricity. Globally, coal and gas are still the primary fuels used to produce electricity.[20] Humanity's reliance on burning carbon, is of course, nothing new. From the campfires of Peking Man to the furnaces of the Industrial Revolution, the carbon burning process has been found at the centre of the cultural and technological progress of the homo genus for at least the past 500,000 years.[21] Still, since the invention and the widespread adoption of electricity, fire has receded from view, it has become estranged, and with that estrangement came a deepening of the global ecological crisis.

The data centre could be considered *the* architectural icon of the fourth Industrial Revolution, the digital revolution. The architectural icon of the first Industrial Revolution is arguably the ironworks. To better understand the data centre as a technical object, it is helpful to look at the ironworks as both buildings share the technical essence of being an industrial fire container. This article is an attempt to make visible the industrial processes of data processing. When the first factories began proliferating across the British landscape, artists of the early romantic period were driven by a similar desire to understand and foreground the cultural and ecological consequences of these buildings.

19 Ibid.

20 Hannah Ritchie, "Electricity Mix," 2020. Accessed January 22, 2021. https://ourworldindata.org/electricity-mix.

21 For a detailed study on true labour cost of producing primitive fire see William Nordhaus, "Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggests Not," Cowles Foundation Discussion Papers, no. 1078 (1994). Accessed August 31, 2021. https://cowles.yale.edu/sites/default/files/files/pub/d10/d1078.pdf.

Fig. 4: “Coalbrookdale at Night” by Philip de Loutherbourg, 1801. Source: https://en.wikipedia.org/wiki/Coalbrookdale_by_Night#/media/File:Philipp_Jakob_Loutherbourg_d._J._002.jpg

The following is a description of the action in Philip de Loutherbourg’s 1801 painting “Coalbrookdale at Night” (fig. 4). Flames surge forth; smoke billows; men toil “over smelted iron—half heroes, half demons,” beheld by spectators from the “threatened rural idyll.”[22] The painting is a romantic depiction of the Bedlam furnace at the Madeley Wood Ironworks, located in Coalbrookdale, Shropshire, England. The Bedlam furnace is perhaps the world’s first coke-fired blast furnace. Constructed from observations made while travelling from Shropshire to Wales between 1786 and 1800, the painting represents the new industrial processes that began to proliferate across the English countryside during this period. Agriculturist Arthur Young described the countryside surrounding Madeley Wood as “too beautiful to be much in union with the variety of horrors spread at the bottom; the noises of forges, mill, with their vast machinery, the flames

22 “Coalbrookdale by Night,” Science Museum Group. Accessed August 31, 2021. https://collection.sciencemuseumgroup.org.uk/objects/co65204/coalbrookdale-by-night-oil-painting.

bursting from the furnaces with the burning of coal and the smoke of the lime kilns."[23] Coalbrookdale's flames are symbolic of the economic and productive power of the ironworks and a critique of the environmental damage caused by these new technologies. The scientific discoveries of the Enlightenment invigorated artists to capture the "truth to nature" of their subjects. They aspired to create objective images', free from human interference.[24] De Loutherbourg's impulses were less conventional, his work being a "paradoxical mix of the mechanical and empirical with the aesthetic and spiritual." His practice confused his critics; was he an "artist or mechanic?" De Loutherbourg had a reputation as a mystagogue and as a deeply read occultist philosopher, and for a time, briefly acted as a mesmeric healer. His early landscape works garnered attention for their "extreme effects and their dramatic, climactic subjects." This eye to represent a heightened sense of drama was consistent across his painting, set design, and theatre designs: "Never were such romantic and picturesque paintings exhibited in that theatre before. They gave you an idea of the mountains and waterfalls, most beautifully executed, exhibiting terrific appearance," noted his friend, Henry Angelo.[25] De Loutherbourg's masterpiece was the Eidophusikon, a fusion of art and technology by an artist who was both painter and mechanic. Described as a "new species of painting" and a forerunner of cinema and virtual reality, the Eidophusikon was designed as an immersive and time-based installation combining moving image, sound effects, and lighting.[26] Artist William Henry Pyne describes Loutherbourg's evocation of the Palace of Pandemonium from Milton's *Paradise Lost*: "Here, …stretching an immeasurable length between mountains, ignited from their

23 Mike McKiernan, "Philip Jacques de Loutherbourg: Coalbrookdale at Night (1801): Oil on canvas, 68 × 106.5 cm. Science Museum, London," Occupational Medicine 58, no. 5 (August 2008): 316–317.

24 Lorraine Daston and Peter Galison, "The Image of Objectivity," Representations 40 (1992): 81.

25 Ann Bermingham, "Technologies of Illusion: De Loutherbourg's Eidophusikon in Eighteenth-Century London," Art History 39 (2016): 377–380.

26 Ibid., 380.

bases to their lofty summits with many coloured flames, a chaotic mass rose in dark majesty, which gradually assumed form until it stood, the interior of a vast temple of gorgeous architecture, bright as molten brass, seemingly composed of unconsuming and unquenchable flame."[27]

Almost two decades later with "Coalbrookdale at Night," de Loutherbourg "brought the purifying furnaces of alchemy into mystical association with new chemical technologies and the furnaces of the Industrial Revolution."[28] In 1952, the British Science Museum purchased the painting, to "fire the imagination of the spectator." The purchase caused heated internal debate. To the Museum's Curator of Metallurgy, Fred Lebeter, the painting was the inaccurate result of the overbearing Romantic imagination, but despite the initial controversy, "Coalbrookdale" still plays an important role in the Science Museum's depiction of the first Industrial Revolution.[29] Coalbrookdale at Night's power comes not from a coolly scientific mechanical objectivity, but instead through the vibrant co-construction of science, experience, myth, and metaphor. In a similar vein, Andrew Blum deploys the metaphor of "mighty rivers," to describe a data centre's energetic force, and its connectedness: "What thrilled me about this room was how legible it made that idea. We are always somewhere on the planet, but we rarely feel that location in a profound way. That's why we climb mountains or walk across bridges: for the temporary surety of being at a specific place on the map. But this place happened to be hidden. You could hardly capture it in a photograph, unless you like pictures of closets. Yet among the landscapes of the Internet, it was the confluence of mighty rivers, the entrance to a grand harbor. But there was no lighthouse or marker. It was all underground, still and dark—although made of light."[30]

27 Christopher Braugh, "Philippe De Loutherbourg: Technology-Driven Entertainment and Spectacle in the Late Eighteenth Century," Huntington Library Quarterly 70, no. 2 (2016): 261.

28 Ibid., 259.

29 Boris Jardine, "Made real: artifice and accuracy in nineteenth-century scientific illustration," Science Museum Group Journal, no. 2 (2014). Accessed August 31, 2021. http://journal.sciencemuseum.ac.uk/pdf/article/2598/made-real.

30 Blum, Tubes, chap. 3, Kindle.

The data furnace

The data centre is an architectural space that actively produces new kinds of thermal ecologies, some of which are dedicated to the comfort of the human, and some of which are dedicated to the comfort of the machine. In 2010, Google's first data centre in St. Ghislain, Belgium, commenced operations. This "green" data centre was designed without the industry-standard (and energy-intensive) chillers which support the cooling systems responsible for server hall refrigeration. Instead, the St. Ghislain server halls are designed to occasionally run hot—the servers are designed to sustain temperatures of up to 45°C. Typically, a server hall has both hot and cold (chilled) aisles, allowing a technician to move between the two to maintain physical comfort. In St. Ghislain, the data centre utilises fresh air to keep server room temperatures within a safe range. On a hot day, the temperature inside the server hall is free to heat up—Google refers to these periods as "excursion hours"—whereby the temperature inside the data centre can rise above 35°C. During excursion hours, humans must vacate the server area. In sweltering conditions, if a worker's blood temperature rises above 39°C, they risk heat stroke or collapse. Above 41°C, delirium or confusion can occur. This temperature level can prove fatal, and even if a worker does recover, they may suffer irreparable organ damage.[31] During "excursion hours, the server hall becomes a human exclusion zone, "too warm for people, but the machines do just fine."[32] The data furnace is not an exclusively industrial process; we are now witnessing its transformation into public utility. In the Dublin suburb of Tallaght, Amazon Web Services is constructing a data centre that, via a district heating system, will recycle its exhaust heat into the local urban network. This includes a hospital

31 "Heat–The case for a maximum temperature at work," TUC. Accessed August 6, 2020. https://www.tuc.org.uk/sites/default/files/Temperature.pdf.

32 Rich Miller, "Too Hot for Humans, But Google Servers Keep Humming," Datacenter Knowledge, March 23, 2012. Accessed August 6, 2020. https://www.datacenterknowledge.com/archives/2012/03/23/too-hot-for-humans-but-google-servers-keep-humming.

campus, a university campus, a cultural centre, and an apartment complex. What appears on the surface as a settled urban matrix is now being reoriented, and plugged into the exhaust pipes of the Cloud. If we shift briefly into a speculative mode; consider an American tech engineer living in a new apartment in Berlin. It is a white Christmas. The engineer returns home from work; the central heating is on. The engineer's mind is tired, and they feel a slight pang of holiday homesickness. Seeking a more profound comfort, they switch on Netflix and select the *Fireplace for Your Home*. They stare peacefully into the recorded flickering flames, and slowly lose themselves in reverie. As one of Amazon Web Services largest clients, it might be fair to speculate that Netflix host their content, at certain times, on the servers at the Tallaght data centre, meaning this engineer, lost in reverie, has set off a series of systemic events that result in a tiny puff of heat radiating from a processor. This exhausted heat is captured, and converted into hot water, reheated again, and delivered to the intensive care unit of a local hospital.

Exosomatic artefacts

For architect Luis Fernández-Galiano, "Architecture can be understood as a material organisation that regulates and brings order to *energy* flows: and, as an *energetic organisation* that stabilises and maintains *material* forms."[33] The data centre is undoubtedly one of the most apparent manifestations of this idea, yet rarely do the spatial phenomenon of the energy flows feature in data centres imaginaries. This paper seeks to redress that imbalance and critically rebuild the data centre as an inseparable entanglement of matter and energy. Moreover, a data centre is a material organization that stabilizes, and disguises, the energy which flows through it. Both the data centre and its energetic flows are exosomatic artefacts—they are of us, but exists outside of us.

33 Luis Fernández-Galiano, Fire and Memory: On Architecture and Energy, trans. Gina Cariño (Cambridge/MA: The MIT Press, 2000), 5-8.

Endosomatic energy feeds the internal metabolism of an organism, i.e. the energy that feeds the human body. Endosomatic energy has a limited threshold of variation; that is, the energy produced and consumed by the human body is predicable within a range, usually between 1500 and 2500 kcal. Humans harness exosomatic energy to maintain our living standards, including heating, transport, food preparation, air conditioning, the building and maintenance of dwellings, and information dissemination. The range variation of exosomatic energy is virtually limitless. Endosomatic energy is biological, exosomatic energy is cultural—the first being a necessity, the second a choice.

The Cloud is a PR construct that easily vanishes into abstraction due to its vast scale. To dissipate the PR illusion, we must make tangible the Cloud's systems of maintenance and supply. The Cloud is not "uninflected by human need" or "distant from us." It is an assemblage of exosomatic artefacts, constructed with vast quantities of rare earth minerals, fuelled in the main by burning carbon, always working for us. The Cloud is beautiful, the Cloud is immense, the Cloud is hungry, the Cloud is thirsty, the Cloud is heavy, and the Cloud is dirty.

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The critical concern of the book “Utopia Computer” is the euphoria, expectation and hope inspired by the introduction of computers within architecture in the early digital age. With the advent of the personal computer and the launch of the Internet in the 1990s, utopian ideals found in architectural discourse from the 1960s were revisited and adjusted to the specific characteristics of digital media. Taking the 1990s discourse on computation as a starting point, the contributions of this book grapple with the utopian promises associated with topics such as participation, self-organization, and non-standard architecture. By placing these topics in a historical framework, the book offers perspectives for the future role computation might play within architecture and society.

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