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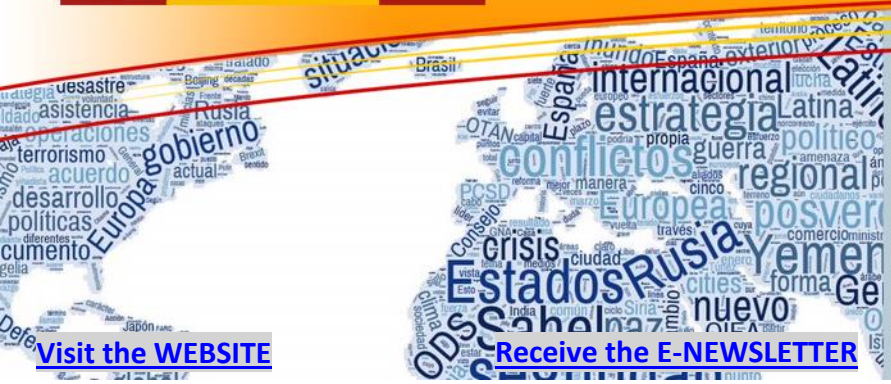
Energy and water consumption in data centers: sustainability risks



Energy and water consumption in data centers: sustainability risks

Abstract:

The use of data has skyrocketed and will do so faster in the coming years as artificial intelligence, the metataverse or the blockchain are implanted in societies. The management and processing of all this data poses important technological, operational and sustainability challenges.

Data centers are skyrocketing energy and water consumption in a context of climate change and population growth. Properly managing the water-energy nexus in the data center sector is one of the great challenges that arise in the next years.

Keywords:

Data center, energy, water, decarbonization, digitization.

El consumo de energía y agua en los centros de datos: riesgos de sostenibilidad

Resumen:

Tras la pandemia el uso de datos se ha disparado y lo hará a más velocidad en los próximos años a medida que se implanten en las sociedades la inteligencia artificial, el metataverso o el blockchain. La gestión y procesamiento de todos estos datos plantea importantes desafíos tecnológicos, operativos y de sostenibilidad.

Los centros de datos están aumentando significativamente el consumo de energía y agua en un contexto de cambio climático y de aumento de la población. Gestionar adecuadamente el nexo agua-energía en el sector de los centros de datos es uno de los grandes retos que se presentan en los próximos años.

Palabras clave:

Centro de datos, energía, agua, descarbonización, digitalización.

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Introduction

We are evolving towards a decarbonised and interconnected world. To think of life without the internet is simply inconceivable[1]. We live naturally with hyperconnectivity, thinking that the data cloud is an ethereal entity. But far from being of this nature, data is processed, moved and stored in centres located, in an uneven distribution, in different regions of the planet.

Data centres are the backbone of the internet and, consequently, of the digital world that governs people's lives every day and will do so increasingly intensely in the future. They store vast amounts of data that are critical to the day-to-day functions of consumers, businesses and public administrations.

The global data centre community anticipates massive growth in the coming years. The total amount of data created, captured, copied and consumed globally is expected to increase rapidly. In 2020, 64.2 zettabytes were reached due to pandemic-driven confinement and the rise of teleworking, digital leisure, online business transactions and virtual classrooms.

By 2025, the amount of global data is expected to increase to more than 180 zettabytes. Considering demographic and technology trends, projections show that by 2023, 5.3 billion people will have access to the Internet and approximately 29.3 billion devices will be connected, with access speeds increasing to an average of 110Mbps[2]. Global internet traffic increased by 23% in 2021[3]

Mobile data traffic is also expected to continue to grow rapidly to quadruple by 2027, and 5G's share of mobile data traffic is expected to increase to 60% by the same year, up from 10% in 2021. Although 5G networks are expected to be more energy efficient than 4G networks, the overall energy and emissions impacts of 5G are still uncertain[4] .

Managing this level of data expansion and processing poses significant technological, operational, not to mention sustainability challenges for data centres. These facilities are driving up energy and water consumption in a context of climate change and population growth. In addition, they also contribute significantly to greenhouse gas emissions.

[1] In the US, one-third of Internet traffic corresponds to Netflix usage. N A T U R E | V O L 5 6 1 | 1 3 S E P T E M B E R 2 0 1 8 | C O R R E C T E D 1 3 S E P T E M B E R 2018

2https://digitalinfranetwork.com/talks/the-pathway-to-net-zero-water-data-centres/meeting-growing-demands-without-causing-further-harm-to-our-planet/

[3] https://www.iea.org/reports/data-centres-and-data-transmission-networks

[4] https://www.iea.org/reports/data-centres-and-data-transmission-networks

The energy consumption of data centres

Data centres are spread heterogeneously around the world. The USA tops the list with 2,701 centres, followed by Germany with 487. The UK ranks third among countries in terms of the number of data centres with 456, while China has registered 443[5] .

Servers and IT equipment housed in these data centres generally need to operate within specific recommended temperature and humidity ranges, otherwise they are prone to degradation and increased risk of failure.

The operation of a data centre means that this type of facility consumes a great deal of electricity, which generates heat. The energy efficiency of a data centre is measured in PEU (Power Usage Effectiveness). The PUE assesses the performance of the data centre by calculating the ratio between the energy used by the centre as a whole and the energy used by the IT equipment alone, taken in isolation[6].

An efficient cooling system is essential to avoid overheating in the limited space of a data centre. In the overall computation of energy used, about 40% of it goes to its cooling systems to maintain a temperature-controlled environment throughout the day. This high energy consumption means that data centres account for up to 5% of greenhouse gas emissions, comparable to the amount emitted by the aviation industry[7].

The figures related to this energy consumption are not negligible. Information and communications technology consumes around 5-9% of the electricity produced in the world. Bitcoin, for example, consumed approximately 105 TWh in 2021, twenty times more than it used in 2016. Ethereum, second only to Bitcoin, consumed around 17 TWh in 2021[8]. Data centres alone are responsible for 2.7% of the EU's electricity demand and their consumption is expected to increase by 3.21% by 2030 if development continues on the current trajectory[9] .

Some smaller countries with expanding data centre markets are experiencing rapid growth in energy consumption. By way of example, electricity use by data centres in

5 https://www.statista.com/statistics/1228433/data-centers-worldwide-by-country/
[6] https://www.data4group.com/es/diccionario-del-centro-de-datos/que-es-pue/
7 https://www.johnsoncontrols.com/en_id/insights/2021/in-the-news/the-challenges-in-keeping-data-centres-sustainable
[8] https://www.iea.org/reports/data-centres-and-data-transmission-networks
9https://digital-strategy.ec.europa.eu/en/library/energy-efficient-cloud-computing-technologies-and-policies-eco-friendly-cloud-market

Ireland has tripled since 2015, accounting for 14% of total electricity consumption by 2021. In Denmark, energy use in the data centre sector is expected to triple by 2025 to account for around 7% of the country's electricity[10].

According to a report by the State Grid Energy Research Institute of China, by 2030, electricity consumption in China's data centre sector will exceed 400 billion kWh, accounting for 3.7% of the country's total electricity consumption[11]. But it is not only the energy consumption, but it is also where it comes from, because in the case of China 73% of these data centres run on coal[12], making it a very important sector in contributing to the emission of greenhouse gases.

Progress is being made in several directions to address the problem of energy sustainability in data centres, both through the use of new cooling technologies and renewable energies and also via the study of new locations, including cold regions or new underwater areas and the clustering of servers in large centres known as hyperscalers. In the latter case, when server utilisation is increased, the number of servers that need to be powered and cooled is reduced, resulting in electricity savings[13].

The use of renewable energy sources in data centres is a solution that is increasingly being implemented to cope with this energy consumption. This also enables them to reduce their greenhouse gas emissions, protect themselves from volatile energy prices and reduce their environmental impact. In this respect, several initiatives are working to measure, track and reduce the environmental impacts of digital infrastructure.

In January 2021, data centre operators and industry associations in Europe launched the Climate Neutral Data Centre Compact (CNDCP), which includes a commitment to make data centres climate neutral by 2030 and has interim targets (2025) for energy efficiency and carbon-free energy use[14].

There is also the 24/7 Carbon-Free Energy Covenant, coordinated by the Sustainable Energy for All Division and the United Nations, which includes three data centre operators: Google, Microsoft and Iron Mountain[15].

10https://www.iea.org/reports/data-centres-and-data-transmission-networks
11http://english.www.gov.cn/statecouncil/ministries/202112/09/content_WS61b13edac6d09c94e48a1f81.html
12 https://www.datacenterdynamics.com/es/noticias/greenpeace-los-centros-de-datos-de-china-funcionan-principalmente-con-carb%C3%B3n-emiten-99-millones-de-toneladas-de-co2/
13 https://www.ibm.com/cloud/blog/are-your-data-centers-keeping-you-from-sustainability
14 https://www.climateneutraldatacentre.net/tag/cndcp-event/
15 https://www.europapress.es/comunicados/internacional-00907/noticia-comunicado-lideres-sector-energetico-lanzan-pacto-energia-carbono-24-20210928160229.html

It is not surprising, then, that hyperscale data centre operators in particular are leading the way in corporate procurement of renewable energy, mainly through Power Purchase Agreements (PPAs)[16]. In fact, Amazon, Microsoft, Meta and Google are the four largest buyers of corporate renewable energy PPAs[17] .

At state level, progress is also being made to combine digital technologies and energy to create a greener ICT infrastructure. By way of example, the largest solar-powered green data centre in Africa and the Middle East is being built in Dubai[18]. This carbon-neutral green data centre will use 100% renewable energy with a capacity of over 100 megawatts.[19]

Furthermore, digital platforms are also moving towards decarbonisation. For example, Netflix is included in a project called DIMPACT to measure and report the carbon footprint of digital services[20].

Not only energy but also water

As mentioned in the previous section, discussions on data centre sustainability tend to focus on what can be done to make facilities more energy efficient and less dependent on fossil fuels, as operators seek to reduce their greenhouse gas emissions and become climate neutral. Consequently, operators have had no choice but to become more transparent about the type and amount of energy they use.

In general, data centres have become more energy efficient by using cooling towers rather than air conditioning. However, this situation is causing another environmental problem that has so far remained hidden[21]: high water use. For some experts, water cooling in data centres is currently one of the best ways to reduce carbon emissions and be sustainable[22]. The worrying thing about this is that most of the water used by data centres generally comes from drinking water sources that supply water to homes and

[16] A PPA (Power Purchase Agreement) is a long-term power purchase agreement or contract between a renewable developer and a consumer.
[17] https://datacenterfrontier.com/cloud-titans-were-the-largest-buyers-of-renewable-energy-in-2021/
[18] https://www.dewa.gov.ae/en/about-us/media-publications/latest-news/2022/08/saeed-mohammed-al-tayer-reviews
19https://www.thenationalnews.com/business/2021/12/18/dewa-breaks-ground-for-the-largest-solar-powered-data-centre-in-the-middle-east-and-africa/
[20] https://dimpact.org/news
21https://digitalinfranetwork.com/talks/the-pathway-to-net-zero-water-data-centres/meeting-growing-demands-without-causing-further-harm-to-our-planet/
22https://techwireasia.com/2022/06/water-cooling-in-data-centres-enhances-sustainability/

businesses. In times of drought this could have serious consequences for local populations.

What is more, in addition to cooling, a considerable amount of water is used to generate energy, especially for fossil fuel-based forms of energy, which are used to power data centres.

Water use, then, is also an important factor in the operation of data centres as it is used both to maintain the operational environment of the facilities and to operate the ICT equipment contained in them. All this points to the need to consider water risk as a critical factor when deciding on where to build or expand data centres[23].

Water is set to become an increasingly scarce resource. According to the World Resources Institute (WRI), by 2030 there will be a 56% global gap between world water supply and demand[24]**.** With this future water crisis looming, pressure is mounting on data centre operators to apply the same level of commitment to water conservation as they do today to ensure that their sites are energy efficient.

Data centres are located all over the world, some in water-stressed regions prone to droughts, water shortages and water restrictions, subjecting companies to operational disruptions due to insufficient water resources. The progression of physical climate risks and the consequent growing problem of unpredictable global water supply could mean the introduction of new water regulations, increasing compliance costs for businesses and potentially restricting the amount of water they are allowed to use[25]. In a water-scarce future, relocating or locating data centres in regions with adequate water supplies is not sufficient.

About 20% of data centres in the United States already rely on watersheds that are under moderate to high stress from drought and other factors[26]. As more data centres emerge, there is a need to know what their demands are and what the impacts are on other consumers[27]. To take one example, in 2019, Google agreed to limit its use of groundwater

[23] https://www.datacenter.cioreview.com
[24] https://www.ecolab.com/news/2021/11/leading-the-way-to-a-positive-water-future
[25] https://www.sustainalytics.com/esg-research/resource/investors-esg-blog/esg-risks-affecting-data-centers-why-water-resource-use-matters-to-investors
[26] https://www.kqed.org/science/1980170/data-centers-backbone-of-the-digital-economy-face-water-scarcity-and-climate-risk
[27] https://www.ft.com/content/8d8bf26f-5df2-4ff6-91d0-369500ed1a9c

in South Carolina following a two-year fight with local groups who had expressed concern that aquifers were being depleted[28].

Santa Clara County in California, home to more than 40 data centres, is experiencing an unprecedented period of drought. Mandatory water use restrictions have been in place since June 2021.[29]

More recent cases have occurred this summer, with several temperature records broken and some data centres seeing their activity questioned due to the impact on water supply. This is the case in London, where Thamer Water has launched an investigation into the impact of data centres on the city's water supply given the restrictions to which the population was subjected during the heatwave[30].

Along with energy, water has become the Achilles' heel of the digital world and large companies are trying to stay ahead of the problem. Google[31], Microsoft[32] and Facebook's parent company, Meta[33], have said they will replenish more water than they consume by 2030. Transparency in water use is also one of the objectives of these large companies. Similar to the PUE, the WUE (Water Use Effectiveness) is being established for this purpose[34].

The danger of moratoriums

Data centres' lack of sustainability is an issue of growing public concern in a context of climate change and high energy prices. This discontent is driving the formation of movements for a moratorium on the construction of data centres, at least until new rules can be established to formalise their contributions to society beyond the provision of digital services.

28https://www.npr.org/2022/08/30/1119938708/data-centers-backbone-of-the-digital-economy-face-water-scarcity-and-climate-ris
29https://www.computerweekly.com/feature/Climate-change-and-datacentres-Weighing-up-water-use
30 https://www.ft.com/content/8d8bf26f-5df2-4ff6-91d0-369500ed1a9c
31 https://sustainability.google/commitments/water/
32 https://news.microsoft.com/es-xl/para-2030-microsoft-reabastecera-mas-agua-de-la-que-consume/
33 https://about.fb.com/es/news/2021/08/devolver-mas-agua-de-la-que-consumimos-para-2030/
34 Mytton, David. (2021). Data centre water consumption. npj Clean Water. 4. 10.1038/s41545-021-00101-w.

Several cases have occurred in recent years. In 2019, the Amsterdam municipal authorities imposed a moratorium to halt the establishment of new data centres in the city until 2020[35].

In February 2022, the Dutch government imposed a nine-month moratorium on new permits for hyperscale data centres while new planning regulations are being drafted. In essence, the new rules will mean that the national government will assume a central role in the licensing of new centres, which until now have been the responsibility of local authorities. The decision does not affect Facebook's planned massive data centre in Zeewolde, nor the plans to build in Eemshaven in Groningen (Google) and Middenmeer in Noord-Holland (Google and Microsoft) because both areas are considered suitable locations.[36]

In Ireland, because of the high share of data centre energy use in national consumption - around 10% - support is also growing for a moratorium on new data centre developments. While the government has stated that there will be no moratorium, it will require that new installations must be able to generate their own power on site[37].

In 2019 in Singapore, a three-year moratorium was also put in place despite being one of the world's top data centre markets, tying with Silicon Valley for second place[38]. The problem is that data centres account for 7% of the country's total energy consumption, a figure which could potentially increase to 12% by 2030[39]. The government has now signalled that it will be more selective in its choice of data centre projects.

Seeking solutions to manage energy and water use in data centres

Combining the exponential growth of society's data usage with more efficient energy use, lowering the carbon footprint and reducing water use are complex challenges for the ICT sector.

[35] https://www.datacenterdynamics.com/en/news/amsterdam-pauses-data-center-building/
[36] https://www.dutchnews.nl/news/2022/02/dutch-call-a-halt-to-new-massive-data-centres-while-rules-are-worked-out/
[37] https://www.datacenterdynamics.com/en/news/ireland-no-moratorium-but-data-centers-may-have-to-have-provide-some-of-their-own-power/
[38] https://www.datacenterdynamics.com/en/analysis/after-the-moratorium-how-singapore-plans-to-stay-in-data-center-race/
[39] https://www.itnews.asia/news/the-challenges-in-keeping-data-centres-sustainable-566090

Companies are developing tactics and strategies and, in some cases, changing their ideas and plans for where they will operate or where they will build their data centres, largely due to the emerging issues of access to clean water and energy.

This pursuit of sustainability in data centres also contributes to an environmentally responsible image for both consumers and investors, who are more supportive of environmentally friendly projects.

Some solutions to achieve sustainability are technical. For example, the replacement of traditional water evaporative cooling systems with innovative closed-loop systems. These systems use recycled water rather than fresh water to reduce the burden on local water systems. Piped water is an even better conductor of heat, allowing centres to be cooled using hot water, which consumes less energy.

Another energy efficiency technique is to ensure that servers are running at full speed for as much of the time as possible, while others are shut down rather than left inactive. Regarding high-density, high-power computing, the most efficient method is to immerse servers in a mineral or non-conductive oil bath[40].

Another solution is to simply locate data centres in cold climates and blow outside air into them[41]. For example, Google and Facebook are talking about building data centres in cooler places like Finland and Sweden rather than hot deserts like Nevada[42].

In China, there is currently an acceleration in the construction of data centres. Innovative projects are being developed to avoid sustainability and pollution problems. In mid-February 2022, China launched a new national project called the "East-West Computing Capacity Diversion Project"[43], which aims to channel the growing demand for computing and data analysis from the more developed eastern regions to the less developed but more resource-rich western regions. According to the Chinese government's announcement, the project will establish eight computer centres and ten data centre clusters. The plan is to build an integrated data centre system by 2025[44]. These data centres will reduce energy use by using immersion cooling technology[45] . Furthermore,

40https://www.silicon.es/experto-opinion/la-refrigeracion-liquida-acelera-su-presencia-en-los-centros-de-datos

41https://www.nature.com/articles/d41586-018-06610-y

42https://www.wbur.org/hereandnow/2019/09/13/china-data-centers-carbon-footprint

43 http://en.people.cn/n3/2022/0220/c90000-9960400.html

44 https://technode.com/2022/05/17/why-does-china-want-to-build-a-national-data-center-system-by-2025/

45 https://technode.com/2022/05/17/why-does-china-want-to-build-a-national-data-center-system-by-2025/

the efficiency of electricity and renewable energy use in the data centres will be significantly improved.

The immersion of data centres in the sea near large metropolitan centres seems to be a growing trend. This is a new type of marine engineering that effectively saves energy and resources and integrates technology, big data, low carbon and green solution, and has far-reaching significance for promoting the green development of the data industry.[46]In fact, there is the precedent of Microsolt's Natick Project off Orkney in Scotland in 2020, which demonstrated that the future of data centres under the sea is reliable, practical and sustainable.[47]

In the case of China, the province of Hainan is especially notable for its development in blockchain. The province has gained strategic importance due to its proximity to Southeast Asia and its isolation from the rest of China. So much so that there are plans to build a large-scale underwater data centre manufactured by China's Offshore Oil Engineering Company (COOEC). [48].

Other underwater data centre projects include Subsea Cloud, which plans to deploy its first subsea capsule near Port Angeles in Washington before the end of 2022, with another deployment planned for the Gulf of Mexico and an interim project (Manannán) in the North Sea[49]. The aim is to demonstrate the practicality of using the ocean to cool a data centre.

The zero use of water, refrigerants and harmful chemicals, the reduced use of land and the possibility of using marine renewable energy are sufficient reasons for further progress in this type of centre to ensure adequate scalability to meet the needs of the increase in data that is expected in the coming years.

Aside from submersion, another option that is gaining momentum is floating data centre projects at sea, especially in countries with land use conflicts, as is the case in Singapore[50].

[46] https://www.datacenterdynamics.com/en/news/work-begins-on-chinese-underwater-data-center/
[47] https://haycanal.com/noticias/14976/el-futuro-de-los-datacenter-bajo-el-mar-es-fiable-practico-y-sostenible
[48] https://technode.com/2020/01/02/blockchain-hub-takes-root-in-chinas-smallest-province/
[49] https://www.datacentermarket.es/mercado/noticias/1135819032609/centros-de-datos-submarinos-mas-eficientes.1.html
[50] read://https_www.geo-tel.com/?url=https%3A%2F%2Fwww.geo-tel.com%2Ffloating-data-centers%2F

Conclusions

With the rapid development of 5G, the Internet of Things, artificial intelligence, industrial internet and the commercial application of these new technologies, the demand for data processing is increasing, which has accelerated the construction of data centres across the globe.

As a consequence of this increasing digitisation, data centres are driving up energy and water consumption in a context of climate change that requires the decarbonisation of economies and the efficient use of water.

Properly managing the water-energy nexus in the data centre sector is one of the major challenges for the coming years. If this is not addressed, conflicts may arise over the prioritisation of the use of these resources between the companies that manage the centres and the populations.

Sustainability concerns, coupled with advances in cooling and heat management technology, have changed the way data centres are designed, managed and maintained. For data centre operators, this includes following energy efficiency best practices, locating new data centres in areas with suitable climates and low water stress, and adopting the most energy-efficient servers, storage, networking and cooling equipment.

Given the high demand for energy and water associated with data centres, there may be conflicts in the prioritisation of these resources, leading to the establishment of moratoriums on their development.

There is a need to encourage rapid technology development to enable data centres to become more sustainable. If this is not the case, the digital world, which we can no longer do without, will come into conflict with the use of vital natural resources such as water.

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